DOCUMENTS EXPEDITING PROJECT

86th Congress
2d Session

COMMITTEE PRINT NO. 2

RELATIVE WATER AND POWER RESOURCE DEVELOPMENT IN THE U.S.S.R. AND THE U.S.A.

REPORT AND STAFF STUDIES

TO THE

COMMITTEES ON INTERIOR AND INSULAR AFFAIRS AND PUBLIC WORKS UNITED STATES SENATE

PURSUANT TO

S. RES. 248

85th Congress, 2d Session

JANUARY 4, 1960

Printed for the use of the Committees on Interior and Insular Affairs and Public Works

UNITED STATES
GOVERNMENT PRINTING OFFICE
49624 WASHINGTON : 1960

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85TH CONGRESS
2D SESSION

S. RES. 248

[Report No. 1926]

IN THE SENATE OF THE UNITED STATES

JANUARY 23, 1958

Mr. MURRAY (for himself, Mr. CHAVEZ, Mr. KERR, Mr. ANDERSON, and Mr. O'MAHONEY) submitted the following resolution; which was referred to the Committee on Interior and Insular Affairs and the Committee on Public Works

JULY 23, 1958

Reported by Mr. O'MAHONEY, with amendments

JULY 28, 1958

Considered, amended, and agreed to; preamble agreed to

RESOLUTION

Whereas in committee print dated December 20, 1957, the chairman of the Committee on Interior and Insular Affairs transmitted a summary of available information on the "Relationships of River and Related Water Resource Development Programs of United States, Soviet Russia, and (Red) China", which on January 23, 1958, was referred to the Committee on Interior and Insular Affairs and the Committee on Public Works for joint hearings;

Whereas testimony at joint hearings again established the fact that the United States is still the leading nation of the world in the production of hydroelectric power, nevertheless the testimony of competent witnesses on the progress of Soviet Russia's water resource development programs is a stern warning that this Nation must not adopt a complacent attitude that would allow us to drift with a false assumption of unassailable superiority: Now, therefore, be it

Resolved, That it is the sense of the Senate that the Committee on Interior and Insular Affairs and the Committee on Public Works continue the joint study and submit their findings and recommendations of ways and means to accelerate the development and utilization of the natural resources of the United States.

MEMORANDUM OF TRANSMITTAL

U.S. SENATE,
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
COMMITTEE ON PUBLIC WORKS,
January 4, 1960.

To the Members of the Committees:

Herewith is the report of your subcommittee following extensive eyewitness inspection during September and October 1959 of the extraordinary river development of the Union of Soviet Socialist Republics relative to the program of the United States of America. Observations, conclusions, and recommendations are embraced herein.

This task was undertaken by direction of the chairmen in fulfillment of instructions embraced in Senate Resolution 248, 85th Congress, 2d session. This required these committees jointly to continue their studies and report thereon. That work has now been accomplished, as far as the U.S.S.R. observations are concerned, and this is our report.

The members of this subcommittee believe that this endeavor resulted in firsthand revelations of a significance that should be brought before the U.S. Senate shortly, as instructed.

Committee members are therefore requested to familiarize themselves with this report. It is intended to bring the report before both the Committee on Interior and Insular Affairs and the Committee on Public Works at an early date for their consideration and review prior to transmittal to the Senate.

In this Committee Print No. 2, Premier Khrushchev's speech of November 28, 1959, has been included as an appendix (see p. 175) because of the insight it provides to the plans and problems of the Soviet electric power industry.

FRANK E. MOSS, *Chairman.*
ERNEST GRUENING.
EDMUND S. MUSKIE.

U.S.-U.S.S.R. MEASUREMENTS AND ABBREVIATIONS

One U.S. dollar brings 4 rubles at the official rate of exchange, 10 rubles at the tourist rate, 20 to 25 rubles on some foreign exchanges.
One ruble equals 100 kopecks.
One hectare equals 2.47 acres.
One acre-foot equals 1,234 cubic meters.
One meter (m) equals 39.37 inches or 3.28 feet.
One cubic meter equals 35.3 cubic feet.
One kilometer (km) equals 0.62 mile.
One square kilometer equals 0.386 square mile or 247 acres.
One megawatt (mw) equals 1,000 kilowatts (kw).
One kilovolt (kv) equals 1,000 volts.

INTRODUCTION

On December 20, 1957, Chairman James E. Murray of the Committee on Interior and Insular Affairs transmitted to the members of the committee a summary of available information on the relationships of river and related water resource development programs of the United States, Soviet Russia, and China. Chairman Murray and Chairman Dennis Chavez, of the Committee on Public Works, arranged joint hearings on this subject early in 1958, under the chairmanship of Senator Joseph C. O'Mahoney.

On July 28, 1958, the Senate unanimously adopted Senate Resolution 248 (Rept. No. 1926) which found that while—

> the United States is still the leading nation of the world in the production of hydroelectric power, nevertheless the testimony of competent witnesses on the progress of Soviet Russia's water resource development programs is a stern warning that this Nation must not adopt a complacent attitude that would allow us to drift with a false assumption of unassailable superiority.

The resolving clause of the resolution declared that—

> it is the sense of the Senate that the Committee on Interior and Insular Affairs and the Committee on Public Works continue the joint study and submit their findings and recommendations of ways and means to accelerate the development and utilization of the natural resources of the United States.

On January 27, 1958, the United States and the U.S.S.R. had agreed to exchange technical and cultural delegations. Following conversations between Chairman Murray and the Honorable William S. B. Lacy, Ambassador in charge of the East-West exchange program, plans were made to send a hydroelectric team, including representatives of the two Senate committees, the Department of the Interior, the U.S. Army Corps of Engineers, the Federal Power Commission, the Tennessee Valley Authority, and interested private organizations to the Soviet Union in the fall of 1958. Senate representatives participated in discussions with officials of the Department of State and the Soviet Ministry of Power Station Construction, who were then in this country, regarding itinerary and time. Winter came before arrangements were concluded.

Early in 1959 the Department of the Interior raised objections to inclusion of nongovernmental observers in the delegation, although the intent of the East-West program was, from the beginning, as far as the United States was concerned, to encourage participation of "private persons and organizations."[1] In August 1959 the chairmen of the Interior and Public Works Committees invited members and

[1] See "U.S. Exchange Programs With the Soviet Union, Poland, Czechoslovakia, Rumania, and Hungary," Committee on Foreign Relations, committee print, Aug. 20, 1959, p. 57.

NOTE.—Photographs throughout this publication are by courtesy of Alex Radin.

The Senate team at Moscow's Vnukova Airport. From the left appear Mapes, Straus, Senator Muskie, Reinemer, Chairman Moss, Senator Gruening, Sneed, Kuljian, McPhail, Ellis, and Radin.

consultants of their committees to make the inspection of Soviet hydroelectric facilities, pursuant to Senate Resolution 248, independent of the East-West exchange route.

At the last moment, at Soviet request and with State Department concurrence, the trip was included under the East-West Exchange Agreement. Under this program, which was renewed and expanded on November 20, 1959, 110 American delegations visited the U.S.S.R. and 105 Soviet delegations visited the U.S. between January 27, 1958, and November 20, 1959. These exchanges were in the fields of agriculture, industry, education, health, medicine, sports, and the arts.

The Senate delegation left the U.S. September 15 and spent 31 days (September 18 to October 19) in the Soviet Union, traveling more than 12,500 miles (approximately 1,000 miles by car, 360 by boat, 340 by train, the remainder by air) inspecting 11 dams (4 under construction) on 8 rivers, 4 hydroelectric institutes, 4 construction towns, a generator manufacturing plant, a thermal station, a power substation, Lake Baikal (a natural reservoir in Siberia which stores more water than all 5 of the Great Lakes combined), a collective farm, a state farm, and a school.

Members of the delegation were:

Senator Frank E. Moss, chairman.

Senator Ernest Gruening.

Senator Edmund S. Muskie.

Hon. Clyde Ellis, general manager, National Rural Electric Cooperative Association, Washington, D.C., and former member of Congress from Arkansas.

Harry Kuljian, president, Kuljian Corp., Philadelphia.

Milton C. Mapes, Jr., Senate Interior Committee professional staff.

Harvey McPhail, chief, Hydroelectric Division, Kuljian Corp., Philadelphia, and former Assistant Commissioner of Reclamation for Power.

Alex Radin, general manager, American Public Power Association.

Vic Reinemer, executive secretary to Chairman Murray.

Theo W. Sneed, Senate Public Works Committee professional staff.

Michael W. Straus, consultant to Senate Interior Committee and former Assistant Secretary of Interior and U.S. Commissioner of Reclamation.

Senator Moss and Senator Gruening are members of both the Interior Committee and the Public Works Committee. Senator Muskie is a member of the Public Works Committee. Messrs. Ellis, Kuljian, McPhail, and Radin traveled at their own or their organizations' expense, as nonpaid consultants to the Interior and Insular Affairs Committee for the duration of the trip.

The itinerary of the delegation was as follows:

Termini	Date	Travel medium	Statute miles
Washington to New York	Sept. 15	Air	205
New York to Copenhagen	Sept. 15–16	do	3,836
Copenhagen to Helsinki	Sept. 17	do	554
Helsinki to Moscow	Sept. 18	do	555
Moscow to Noginsk	Sept. 23	Auto	36
Noginsk to Moscow	do	do	36
Moscow to Tbilisi	Sept. 25	Air	1,230
Tbilisi to Khrami GES 1 and 2	Sept. 27	Auto	75
Khrami GES 1 and 2 to Tbilisi	do	do	75
Tbilisi to Sochi	Sept. 28–29	Train	338
Sochi to Krasnaya Polyana GES	Sept. 30	Auto	56
Krasnaya Polyana GES to Sochi	do	do	56
Sochi to Rostov	Oct. 1	Air	295
Rostov to Stalingrad	Oct. 1–3	Boat	353
Stalingrad to Kuybyshev	Oct. 5	Air	430
Kuybyshev to Lenin GES	Oct. 6	Auto	56
Lenin GES to Kuybyshev	do	do	56
Kuybyshev to Moscow	Oct. 7	Air	600
Moscow to Novosibirsk to Irkutsk	Oct. 9	do	2,775
Irkutsk to Bratsk	do	do	280
Bratsk to Irkutsk	Oct. 10	do	280
Irkutsk to Listvyanka	Oct. 11	Auto	40
Listvyanka to Irkutsk	do	do	40
Irkutsk to Novosibirsk to Sverdlovsk to Leningrad	Oct. 13–14	Air	2,970
Leningrad to Moscow to Khar'kov	Oct. 17	do	805
Khar'kov to Kremenchug	do	Auto	170
Kremenchug to Khar'kov	Oct. 18	do	170
Khar'kov to Moscow	do	Air	400
Moscow to Vilnius to Warsaw	Oct. 19	do	684
Total distance traveled within the Soviet Union, exclusive of intracity travel.			12,558

The dams visited (in chronological order), their construction status and installed capacity, and the rivers on which they are located are as follows:

Dam	Status	Capacity (kilowatts)	River
Za GES	Completed 1927	36,800	Kura.
Khrami No. 1	Completed 1949	112,800	Khrami.
Khrami No. 2	Advanced construction	110,000	Do.
Krasnaya Polyana	Completed 1950	28,000	Mzymta.
Tsimlyanskaya	Completed 1952	164,200	Don.
Kuybyshev (also known as Lenin GES or Volzhskaya).	Completed 1957	2,300,000	Volga.
Stalingrad	In operation	2,530,000	Do.
Irkutsk	Completed 1959	660,000	Angara.
Bratsk	Advanced construction	4,600,000	Do.
Kremenchug	do	624,000	Dnieper.
Gyumush	Completed 1953	224,000	Razdan.

The hydroelectric research institutes visited were the Scientific Research Section of Hydro-Project Institute, Moscow; Science Institute for Hydroelectric Technology, Tbilisi; All-Union Hydroelectric Projects Design Institute, Leningrad; and the All-Union Scientific and Investigation Institute for Hydro-Techniques, Leningrad.

The delegation also visited the construction cities of Volzsky (Stalingrad Dam) and Khrushchev (Kremenchug Dam) and the construction towns at Khrami No. 2 and Bratsk, the Electrosila manufacturing plant in Leningrad, Thermal Station No. 2 in Leningrad, the Noginsk power substation near Moscow, Digomy State Farm in Georgia, Put Ilytcha Collective Farm in Siberia, and traveled by boat through the Volga-Don Canal.

Throughout the trip members of the delegation studied assigned topics to assure maximum coverage and minimum duplication. Their individual reports appear after the following summary, conclusions, and recommendations.

UNITED STATES SENATE
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS
TRIP TO THE SOVIET UNION SEPT. OCT. 1959
BRATSK

Prepared by U.S. ARMY,
CORPS OF ENGINEERS,
ARMY MAP SERVICE
WASHINGTON
NEW YORK

49824 O - 60 (Face p. X) No. 2

UNITED STATES SENATE
ITTEE ON INTERIOR AND INSULAR AFFAIRS
P TO THE SOVIET UNION SEPT.-OCT. 1959

RELATIVE WATER AND POWER RESOURCE DEVELOPMENT IN THE U.S.S.R. AND THE U.S.A.

SUMMARY AND CONCLUSIONS

BACKGROUND

Some 30 years ago the Russians set themselves to the task of becoming competent in the field of water resource development. This they did initially by employing foreign engineers, importing foreign-built equipment, and training engineers in foreign universities. They studied development and theory in several other countries, but particularly the United States. It is to the Russians' credit that, building on the experience and technology thus acquired, they have now caught up with the rest of the world in the general field of hydroelectric development. In fact they are actually preeminent in certain specific aspects of such development.

The Russians have long recognized that their mighty river systems constitute one of their greatest inexhaustible resources. This recognition, plus the fact that Soviet engineers were competent in hydroelectric technology while trailing other nations in thermal-electric techniques, influenced the Soviets to push their program of hydroelectric development with particular vigor. This decision was made easier by their early and continued recognition that hydroelectric power, in the U.S.S.R. as in the U.S., is normally cheaper than electricity generated from other sources. This emphasis has resulted in the proportion of hydropower in their systems rising from less than 2 percent in 1925 to approximately 20 percent in 1958, a ratio which Soviet engineers and the Soviet Government find quite satisfactory.

In the U.S.A., as in the U.S.S.R, about 20 percent of the power is generated hydroelectrically and 80 percent by thermal stations. The Soviets intend to maintain this ratio for some time to come. In the United States the 20 percent is a single point on a downward curve dropping from 35 percent in 1946 to an estimated 15 percent by 1970, and approximately 12–14 percent in 1980.

Also in the U.S.S.R. as in the U.S., atomic power is not expected to supply significant amounts of power during the next few years. The U.S.S.R. regards conventional sources, both thermal and hydro, as more economic and expeditious in providing electric power capacity. Authoritative sources say that the Russians will have an atomic power capacity of 515,000 kilowatts in 1962 or somewhat later.

MULTIPURPOSE ASPECTS OF SOVIET WATER RESOURCE DEVELOPMENT

In the development of water resources in the Soviet Union priorities of utilization are as follows:

1. Hydroelectric power.
2. Navigation.
3. Irrigation.
4. Flood control.
5. Fish, wildlife, and recreation.
6. Water supply.

POWER PRODUCTION

The U.S.S.R. is catching up with the U.S. in electric power production, the basic field in which supremacy counts heavily in peaceful economic competition or in event of war.

Although the U.S. is still far ahead, with 142 million installed kilowatts at the begining of 1959, compared with 53 million in the U.S.S.R., the Russians could overtake us in 1975—in 15 years—unless we speed up or they slow down.

The U.S.S.R. allocates almost four-fifths of its power to industry. The U.S. uses a far smaller share of its power in goods-producing industry. This means that the U.S.S.R. could surpass the U.S. in the amount of power allocated to industry in 1973—in 13 years.

The U.S.S.R., vigorously pursuing its oft-stated goal of overtaking the U.S. in economic production, has undertaken literally hundreds of new starts on hydroelectric developments within the past 5 years.

The Soviet power program has produced the largest hydroelectric stations in the world, yielding the greatest project volumes of electricity from the largest generators connected by the longest transmission lines operating at highest voltage. During the 7-year plan (1959–65) it is planned to install about 12 million kilowatts of new hydroelectric capacity, in comparison with the 7.4 million kilowatts installed during the previous 7 years (1952–58).

The U.S.S.R. constructs big hydroelectric dams faster than the U.S. does. This is because (1) authoritarian governments move faster than democracies, with fewer built-in safeguards, and with less review, appropriation, and relocation problems; (2) in many instances powerplants are under construction on a round-the-clock and round-the-calendar basis, and (3) Soviet engineers make extensive use of prefabricated concrete forms and sections, pour concrete in freezing weather using insulated forms and electric or steam heat, and use other timesaving construction techniques, none of which can be regarded as a scientific breakthrough.

As a case in point we cite Kuybyshev Dam on the Volga River. This world's largest dam in terms of power output, with an installed capacity of 2.3 million kilowatts, was begun in 1950, when hundreds of engineers began its design. Simultaneously crews cleared the area, then built access roads and a permanent site city. Work on the dam proper began in 1952, and it was in full production in 1957.

Bratsk Dam on the Angara River in Siberia was begun in 1956 and is scheduled for completion in 1963. It is almost twice the size of Kuybyshev, since it will have an installed capacity of 4.5 million kilowatts. The engineers in our delegation accepted the contention

of the Soviet engineers in charge at Bratsk that they would complete this dam ahead of schedule.

Starting much earlier in its hydroelectric program, the U.S. has developed almost three times as much hydroelectric power as the U.S.S.R. However, the U.S.S.R. has about three times as much potential hydropower as does the U.S.

The greatest undeveloped hydropower potential on the North American Continent is concentrated in Alaska. The full hydro potential of this new State has not been fully determined yet. But the U.S. Geological Survey identified 12 million hydro kilowatts in Alaska in 1954 and after additional surveys the Federal Power Commission recently raised this estimate to 19 million potential kilowatts. This approaches 20 percent of the total undeveloped potential in the United States, estimated at 111 million kilowatts.

POWER TRANSMISSION

The development of transmission lines in the U.S.S.R. has kept pace with the development of generating capacity. In 1958 there were nearly five times as many total miles of transmission lines as in 1940. The average annual growth in this field approaches 9 percent. The Soviet Union plans to have 178,000 miles of transmission lines by 1965, a projected average annual increase of 20 percent.

In contrast the average annual increase in the U.S. from 1948 to 1957 was 3½ percent. Total U.S. mileage of all transmission lines of 22 kilovolts and higher increased from 229,334 to 306,749 during this period.

The overall projected capital investment in U.S.S.R. power development during the current 7-year plan is 127 billion rubles, an increase of about 70 percent over the previous 7 years. The projected investment in transmission is expected to increase 312 percent, from 8 to 33 billion rubles.

During the current 7-year plan the U.S.S.R. is constructing five integrated transmission systems, the European-Urals, Central Asian, Central Siberian, Trans-Caucasian, and Northwest networks.

The U.S.S.R. plans to tie these five regional grids into one integrated national network, with Eastern Siberia coming in somewhat later.

The efficiency and economy of shifting peak power loads over a geographic area that embraces seven time zones from Leningrad to Vladivostok is apparent to any housewife whose lights have dimmed at dinnertime when electrical use is heavy. The Soviet plan is in sharp contrast with the absence of planned or actual transcontinental transmission interties in the U.S. and the lack of even local interties in many parts of the U.S.

Long distances from some dams to industrial areas in the U.S.S.R., plus the needs of their regional and national grids, require high-voltage transmission. The heaviest U.S. transmission lines are 345 kv. The Russians operate a number of 400 kv lines, which are being stepped up to 500 kv, at which they have been tested successfully. Soviet engineers are contemplating use of alternating current transmission of 700 and 1,000 kv, and direct current transmission at 800 kv. At 800 kv d.c. they expect power losses of only 4 percent for lines

about 600 miles long as compared with the 7½ percent now being lost on the 400 kv a.c. lines from Kuybyshev to Moscow (600 miles). Line losses decrease as transmission voltages increase.

POWER DISTRIBUTION

Development of big power installations and regional and national grid systems is the most important factor in supplying electric power to large urban areas and the farms.

An indication of the economies to be achieved is shown by Soviet statistics that cost per kilowatt of capacity of a 5,000 kw thermal plant is 2½ to 3 times as much as the cost per kilowatt of capacity of a 200,000 kw plant. More than 100,000 tiny, low efficiency electric powerplants in the U.S.S.R. presently produce about 10 percent of the total amount of power, at a cost of from 1 to 2 rubles (100–200 kopecks) per kilowatt. About 800,000 operating and servicing personnel are required for these stations.

In contrast, the large electric powerplants which produce 90 percent of the country's total electric power do so at an average cost of less than 8 kopecks per kilowatt with less than 200,000 operating and servicing personnel. Thus 1 employee at a big station moves as many kilowatts as 36 at a small station.

The Soviet Union apparently has no immediate plans for passing on to residential consumers the benefits of savings achieved through the economies of larger generating units tied together in regional grids. Cost of electric power to the residential consumer in urban areas is fixed nationally at 40 kopecks per kilowatt-hour. Contrary to practice in the U.S., no block rates are available. On the other hand, rates for industry vary considerably from region to region and from industry to industry, with some industries charged as little as about 10 kopecks per kilowatt-hour.

Seventy percent of the Russian cities are now part of interconnected grid systems, but little more than half of Russia's farm establishments and less than half of her farm homes are electrified by interconnected system, or even by a local plant. Ninety-seven percent of U.S. farms and farm homes are electrified.

Nearly half of the U.S.S.R.'s 210 million people—as contrasted with approximately 10 percent of the 177 million in the U.S.—are engaged directly in agriculture.

The current Soviet 7-year plan calls for a 70 percent increase in agricultural production. Most major crops in the U.S.S.R. are plowed, seeded, and harvested with tractor machinery. Thus rural electrification, which replaces and releases manpower and raises health standards, is one of the means by which the U.S.S.R. may achieve its agricultural goal. The full application of electric power to farms and farm homes in the U.S.S.R. would probably do as much as any other single thing to improve agricultural efficiency and help to release up to 60 million people from the land to other sectors of the economy. The Soviet Union has the population, land, and material resources to attain its agricultural goals.

We saw no crash program in agriculture, but the crash program in electric power development which we saw could help to lay the groundwork for a similar advance in agriculture.

POWER ORGANIZATION

Organizationwise, the Ministry of Power Station Construction builds all major electric powerplants, constructs high voltage power line systems and substations, and handles assembly of powerplant equipment, makes surveys, and conducts powerplant planning. Initial planning for power supply starts at the level of each of the 104 economic regions, goes up to the Council of Ministers in each of the 15 Republics in the U.S.S.R., then to the All-Union Council of Ministers, which operates through the All-Union Planning Commission (Gosplan). Going back down the ladder Gosplan allocates funds from the national treasury. Local economic regional councils may build some small projects but the Ministry of Power Station Construction builds the big ones. Operation of all plants and transmission networks is under the control of the regional economic councils.

The ability and performance of Soviet engineers is good. Using as a base the engineering knowledge and experience accumulated by other countries, they have advanced their own techniques rapidly during the past 20 years, particularly in the past decade.

Design, construction, and machinery in these dams is all-Russian, and has been for about 9 years.

We saw in operation single hydro generator units larger than any elsewhere in the world (nameplate rating of 115,000 kw as compared with 108,000 kw at Grand Coulee). Generators of 225,000 kw each are being designed for Bratsk Dam and 500,000 kw units are planned for Krasnoyarsk Dam.

Additionally, the U.S.S.R. is exporting heavy power equipment to more than 20 countries, many of which the U.S. formerly served. We saw test models of Egypt's Aswan Dam in a Soviet hydroelectric laboratory. The Russian construction engineer who built Kuybyshev Dam revealed to us that he has been designated as the Soviet construction engineer for Aswan, the generators for which are being designed by Electrosila in Leningrad.

We visited at length with several of the top Soviet engineers who have been serving for several years as consultants in Communist China, which country has embarked upon a program aimed at developing 70 million kilowatts in hydropower by 1970, incidental to the main purpose of the Chinese dams which, as historically, is flood control.

One of several projects of over a million kilowatts each is scheduled for completion next year in Red China. A 3 million kilowatt plant is presently under construction. The delegation also discovered that the Ichang Gorge Dam on the Yangtze River, planned at 15 million kilowatts during World War II by John Savage of the U.S. Bureau of Reclamation, is now being designed by Chinese and Soviet engineers for a first-stage capacity of 25, later going to 40, million kilowatts. (This will be 12 to 20 times the size of Grand Coulee, the largest dam in terms of power production in the U.S.)

NAVIGATION

The 80,000-mile inland waterway system of the U.S.S.R. handles 5.4 percent of the total freight of the country. Development of navigation is hampered because most freight traffic normally flows east and west and the rivers, for the most part, flow north and south.

Navigation on many streams is limited by ice conditions during from 4 to 6 months a year. Inland waterway freight movement has doubled since 1950 and an increase of an additional 60 percent is planned by 1965. The Volga River system carries the most freight. Completion of the Volga system of 12 dams (8 are already completed or under construction) will provide a channel 10 feet or deeper over 2,000 miles of the main stream.

The Volga-Don Canal links the Black and Caspian Seas. The Volga is also connected with Moscow by a 75-mile canal. A 300-mile canal connects the Volga River system through Lake Onega with the Stalin Canal system which joins the Baltic and White Seas. The Soviet inland waterway system thus links all of the four seas bordering European Russia.

IRRIGATION

The U.S. and U.S.S.R. have approximately equal amounts of land under irrigation. Huge irrigation projects are reported in central Asian areas which we did not visit. At Stalingrad and other projects we visited it was evident that irrigation is developed with far less intensity than hydroelectric features of multipurpose development. But the U.S.S.R. plans to develop irrigation in these areas at a later date.

FLOOD CONTROL

Flood control is not a major problem in the Soviet Union. Floods are seasonal, high, and regular, and there has been little development in the flood plains. Levees and floodwalls have been constructed around urban areas, particularly where the reservoirs encroach on such areas. Improved concrete-lined channels, supplemented by dikes or floodwalls, have been provided to carry streams through many of the older cities. The large multipurpose reservoirs we saw and those soon to be filled will, of course, have an inherent value for flood control purposes.

FISH, WILDLIFE, AND RECREATION

Management of the salmon in the Columbia River Basin requires a much more ambitious program of fish management in this country than is needed in the U.S.S.R. The Soviet Government does not remove rough fish from the reservoirs on a large scale, as we do, on the theory that most, if not all, fish are desirable. Fish is a major food in the U.S.S.R., as we were reminded daily, and various fish passage facilities are in operation. In Stalingrad we saw under construction unique fish locks through which the fish will pass along with ships.

Soviet use of reservoirs for recreation purposes does not begin to approach the level enjoyed in this country. However, we saw a number of recreational facilities along reservoirs and were told that similar facilities, including beaches, rest homes, sanitariums, boathouses, and fishing camps, are planned at other projects.

WATER SUPPLY

Serious water pollution, particularly from industrial sources, reduces the use of certain water sources for water supply, recreational

purposes, and fish and wildlife propagation. While a number of major cities have safe, central water supply systems, many others do not. The Russians have not concerned themselves seriously with providing unpolluted water supplies.

RELOCATION AND REDEVELOPMENT

Relocation of many towns and building of new cities is required by dam construction in the U.S.S.R. Construction of Kuybyshev Dam required relocation of about 150,000 people, and 100,000 people were relocated from the reservoir area behind the Kremenchug project on the Dnieper.

Settlement is made for buildings, railroads, and other property taken in the reservoir area. Permanent cities are built at the construction site, to house construction workers and their families and later the industrial workers who follow to work in plants planned and built in the immediate area to use at-site power.

BIG INVESTMENT IN FULL WATER RESOURCE DEVELOPMENT

Despite a very limited consumer goods economy, the Soviet Union is spending billions in water resource development, particularly in the hydroelectric field, and is pressing forward with a carefully planned program with the ultimate goal of the fullest comprehensive development of its great water resource potential.

RECOMMENDATIONS

In the context of our economic competition with the U.S.S.R. in the field of electric power development, in the light of the great progress being made by the Soviet Union as recounted in this report, and because of the benefits such actions will bring to the American people, we recommend—

(1) An accelerated effort in the United States to develop fully our water resources with particular attention to utilization for production of hydroelectric power the waters now wasting into the seas.

(2) That the Senate, through its appropriate committees, conduct a thorough and continuing study of—

(*a*) The most efficient organization of the national power-supply function with a view to assuring to the entire Nation at the earliest possible time the full advantages of modern power-supply technology; and

(*b*) How the planning function in the electric power industry can be rationally established on a national basis to assure the early and continued maximum application of the latest scientific techniques and the fullest possible use of our thermal and atomic fuel resources, our hydroelectrical potential, and our geographically limited supplies of water.

(3) That the Federal Government continue and expand its program of transmission line construction to interconnect and market power from Federal projects and, where feasible, to transmit privately generated power.

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(4) That the Congress consider establishing a system of Federal accounting which would—

(*a*) Make a clear distinction between operating expenses and capital investment in the expenditure of appropriated funds;

(*b*) Keep a current account of the capital assets held by the Federal Government in trust for the people; and

(*c*) Provide realistic periods of amortization in accounting for Federal capital investments, in accord with the actual service life of the property involved.

(5) Prompt passage of S. 2549, the Resources and Conservation Act,

(*a*) to provide for an annual review of our resource situation and recommendation of national resource policies prepared by a Resources and Conservation Council in the Executive Department;

(*b*) to promote conservation, development, and utilization of resources; and

(*c*) to establish a Joint Committee on Resources and Conservation in Congress to study continuously our resource position and policies.

(6) That the Federal Government—

(*a*) Encourage speedy completion of the job of bringing electric service to the 2 million unserved rural U.S. citizens; and

(*b*) Recognize the desirability of all Americans enjoying the benefits of abundant electricity at reasonable cost, and continue to make available low cost power as necessary to accomplish this purpose.

(7) That this report be considered as full discharge only of the specific responsibilities entrusted to this subcommittee to "continue the joint study" as to the "relationship of river and natural resource developments" of the U.S.A. and U.S.S.R. Because it embraces much positive, new, and heretofore unavailable factual information which the Senate desired and now has for its deliberations, it is recommended that this report be formally accepted on its merits by Senate resolution, endorsed by the parent committees.

This subcommittee recognizes that its authority derived from Senate Resolution 248, but this report is not exhaustive of that authority.

In view of these circumstances, it now appears appropriate to amend and bring up to date Senate Resolution 248, passed unanimously in the 85th Congress, 2d session.

SUGGESTED AMENDED RESOLUTION

Whereas the Senate by committee action, public hearings, and floor vote on Senate Resolution 248 has been engaged in a continuing study of the relative water resource and related development programs of the United States and Soviet Russia, since 1957; and

Whereas that endeavor through the joint efforts of the Committee on Interior and Insular Affairs and the Committee on Public Works has now resulted in a factual, eyewitness report revealing the remark-

able effort and accomplishment of the Union of Soviet Socialist Republics to overtake and then surpass the United States of America in this vital field: Now, therefore, be it

Resolved, That this report be received, accepted, ordered printed, and referred to the Committee on Appropriations, Committee on Interior and Insular Affairs, and the Committee on Public Works for appropriate consideration in relation to their other duties; and be it further

Resolved, That it is the sense of the Senate that the Committee on Interior and Insular Affairs and the Committee on Public Works continue the joint studies as previously requested, including, as appropriate, securing similar information concerning developments in Communist China and elsewhere, and continue also, as previously requested, to submit their recommendation of ways and means to accelerate the development and utilization of the natural resources of the United States.

Respectfully submitted.

Senator FRANK E. MOSS,
Chairman.
Senator ERNEST GRUENING.
Senator EDMUND S. MUSKIE.

WASHINGTON, *December 1959.*

STAFF STUDIES

Relative Scope, Velocity, and Size of U.S.S.R. and U.S. Power Programs---------- Michael W. Straus

Hydroelectric Development in the Soviet Power System---------- Milton C. Mapes, Jr.

Power Development and Transmission Systems in the U.S.S.R---------- Harry A. Kuljian and Harvey F. McPhail

Electric Service to Urban Areas in the Soviet Union-- Alex Radin

Soviet Agriculture and Electric Power---------- Clyde T. Ellis

Organization for Electric Power Supply in the Soviet Union---------- Milton C. Mapes, Jr.

Hydroelectric Axis Swings---------- Michael W. Straus

River Development in the U.S.S.R---------- Theo W. Sneed

Irrigation in the U.S.S.R---------- Michael W. Straus

Relationship of Fish Management to Hydroelectric Development in the U.S.S.R---------- Vic Reinemer

Recreational Use of Reservoirs in the U.S.S.R.----Vic Reinemer

Relocations of Population and Industry---------- Theo W. Sneed

Contrasts Between U.S.S.R. and U.S.A-------- Michael W. Straus

STAFF STUDIES

RELATIVE SCOPE, VELOCITY, AND SIZE OF U.S.S.R. AND U.S. POWER PROGRAMS

(By Michael W. Straus)

The Union of Soviet Socialist Republics is driving forward a hydroelectric power program of great scope, velocity, and size.

This power program has achieved proportions of recognized world economic and international political significance.

In scope it spans the plant's largest land mass and is being reflected by actions in China and numerous adjoining satellite Communist nations.

In velocity the U.S.S.R. hydroelectric power program is on an all-out national basis. However, this crash program started so recently that it will be years before the Soviet Union can attain the totals in power production or kilowatt capacity of the United States.

In size this Soviet power program has already produced the largest hydroelectric stations yielding the greatest project volumes of electricity from the largest generators and is being spread over the widest areas by the longest transmission lines operating with the least losses at the highest voltages.

It is currently and continually being augmented by all manners of government actions, including extension of power activities and "new starts" on a wide variety of major construction works specifically designed for this purpose.

It can, and probably will, in the absence of any positive obstacles which were undiscerned by Senate on-the-spot observers, continue to grow until the proclaimed economic goals of the Soviet leaders are eventually attained.

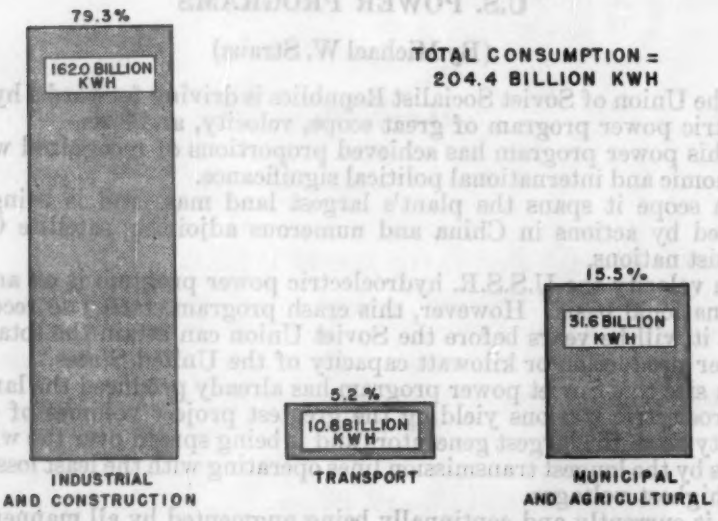
These frequently announced goals of the Soviet Government are, first, overtaking, and then surpassing the United States in installed kilowatt capacity and annual national production of kilowatt-hours. The second Soviet goal is to surpass the United States in what Soviet leaders term "the peaceful economic war of production of goods."

This first goal is of primary import. Part of the economy and "production of goods" admittedly rests on the availability of kilowatts.

Analysis of progress toward the second goal is more subject to any fallacies inherent in deductions on comparisons of kilowatt capacity and production between nations of contrasting population, area, resources, state of economic development, as well as opposite philosophy of government.

In direct response to the Senate's specific instruction by unanimous resolution for a relative study and report in this area of interest, the Senate observers requested their most experienced operator and recognized authority in this field to project conclusions as to attainment of the first-mentioned U.S.S.R. goals, including a time element as to their attainment.

U.S.S.R
CONSUMPTION OF ELECTRIC POWER BY CLASS OF USE—1958



Source: U.S.S.R. Ministry of Power Station Construction.

This was done with the benefit of extensive eyewitness examination of the Soviet program plus discussion and appraisal. The projections herein reported are:

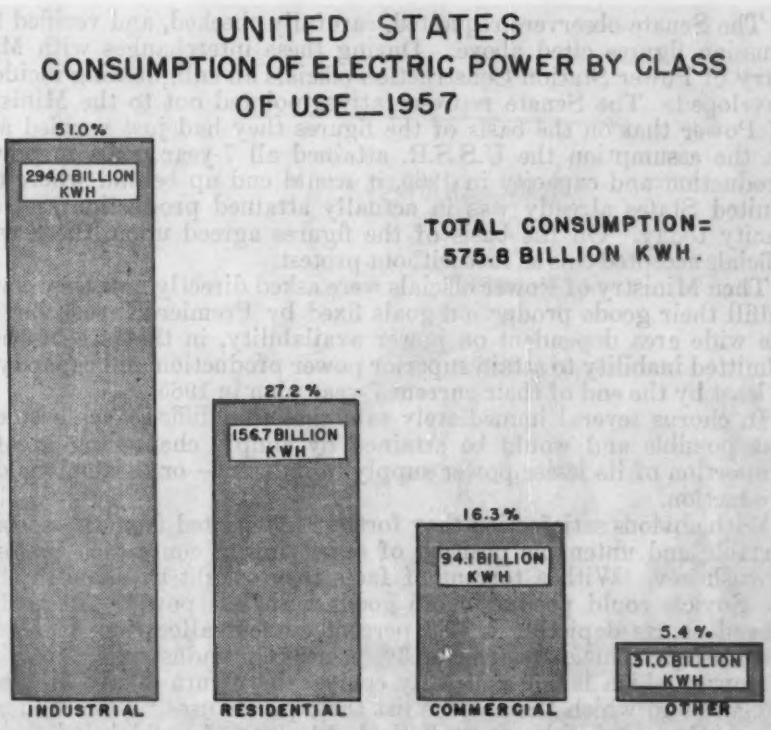
The U.S.S.R. could pass the total kilowatt production of the U.S.A. in 1975—or in 16 years.

The U.S.S.R. could pass the U.S.A. in the allocation of power to industry producing goods in 1973—or in 14 years.

DETAIL ON PROJECTION

In the various, and frequently conflicting, views currently circulated as to when, if ever, the U.S.S.R. might surpass the U.S.A. in power supply and resultant economic goods production (restricted only to the field directly controlled by the availability of electrical energy), a wide area of basic agreement on underlying facts has emerged slowly since Senate committees undertook these studies over 2 years ago. Such areas of general agreement include:

1. The U.S.S.R. relative to the U.S.A. is increasing its power supply at a higher proportion or percentage rate.



Source: U.S. Federal Power Commission.

2. The U.S.A. relative to the U.S.S.R., started earlier, was, and is, ahead in power supply. The U.S.A. had over three times the Soviet's installed capacity and production and per capita use as of 1957.

3. During the prior 7 years the U.S.S.R. drive to electrify lifted it to second place among all nations of the world (the U.S. leading). The Soviets increased their capacity from 22,400,000 to 45,970,000 kw and their production from 90 billion to 210 billion kwh, with lesser percentage increases registered by the U.S.A.

4. In the current all-out 7-year plan covering 1959 through 1965 the Soviets have proclaimed they will increase their capacity from 53 to 113 million kw and production from 233 to 520 billion kwh.

5. The United States during the same period will also lift its production and capacity. Directly comparable figures are unavailable since the United States has no 7-year plan. If it had, owing to differing government philosophy it would be unable to force achievement of goals as the Soviets can with all power capacity and production a completely controlled government prerogative.

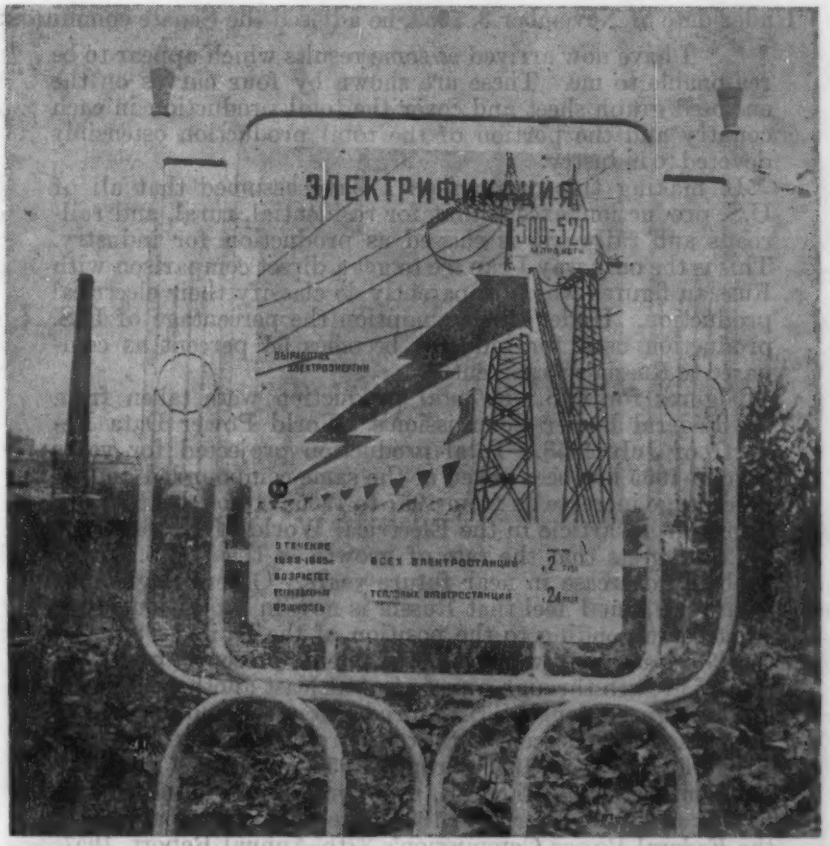
The Senate observers requested, carefully checked, and verified the Russian figures cited above. During these interchanges with Ministry of Power Station Construction officials an enlightening incident developed. The Senate representatives pointed out to the Minister of Power that on the basis of the figures they had just verified and on the assumption the U.S.S.R. attained all 7-year goals in power production and capacity in 1965, it would end up behind where the United States already was in actually attained production and capacity today. On the basis of the figures agreed upon, the Soviet officials accepted this as fact without protest.

Then Ministry of Power officials were asked directly how they could fulfill their goods production goals fixed by Premier Khrushchev in the wide area dependent on power availability, in the face of their admitted inability to attain superior power production and capacity—at least by the end of their current 7-year plan in 1965.

In chorus several immediately said that this difficult achievement was possible and would be attained by simply channeling greater proportion of its lesser power supply to industry—or economic goods production.

With obvious satisfaction they forthwith departed from the uncomfortable and untenable position of appearing to contradict Premier Khrushchev. With a torrent of facts they sought to establish that the Soviets could produce more goods with less power. They displayed charts depicting a 79.3 percent current allocation of power to industry. This exceeds by 28.3% American "industrial" allocation of power, which is not a directly comparable figure due to different categories in which the nations list their power uses. (The Federal Power Commission has a statistical category of use labeled "commercial" of which there is no Russian counterpart. It appears that some, but only a part of this—and how much the FPC cannot say—could be classified as "industrial" by the Soviets in the sense that it is used for the industrial economic production of goods.) The Soviet officials expanded their explanation and justification in a fashion that was mathematically correct and also in accord with established Soivet thinking and practice. They also volunteered some opinions as to American "waste" of power for nonproductive purposes, citing in particular New York's Times Square electric sign advertising and contrasting it with a single neon "white dove of peace" which was the sole skyline electric sign observed from Moscow's Red Square.

The Senate committee on the basis of all this data requested Harvey F. McPhail to provide and refine a "projection" responsive to the Senate instruction for a "relative study" of U.S. and U.S.S.R. advances. Mr. McPhail, a private engineer of wide Government ex-



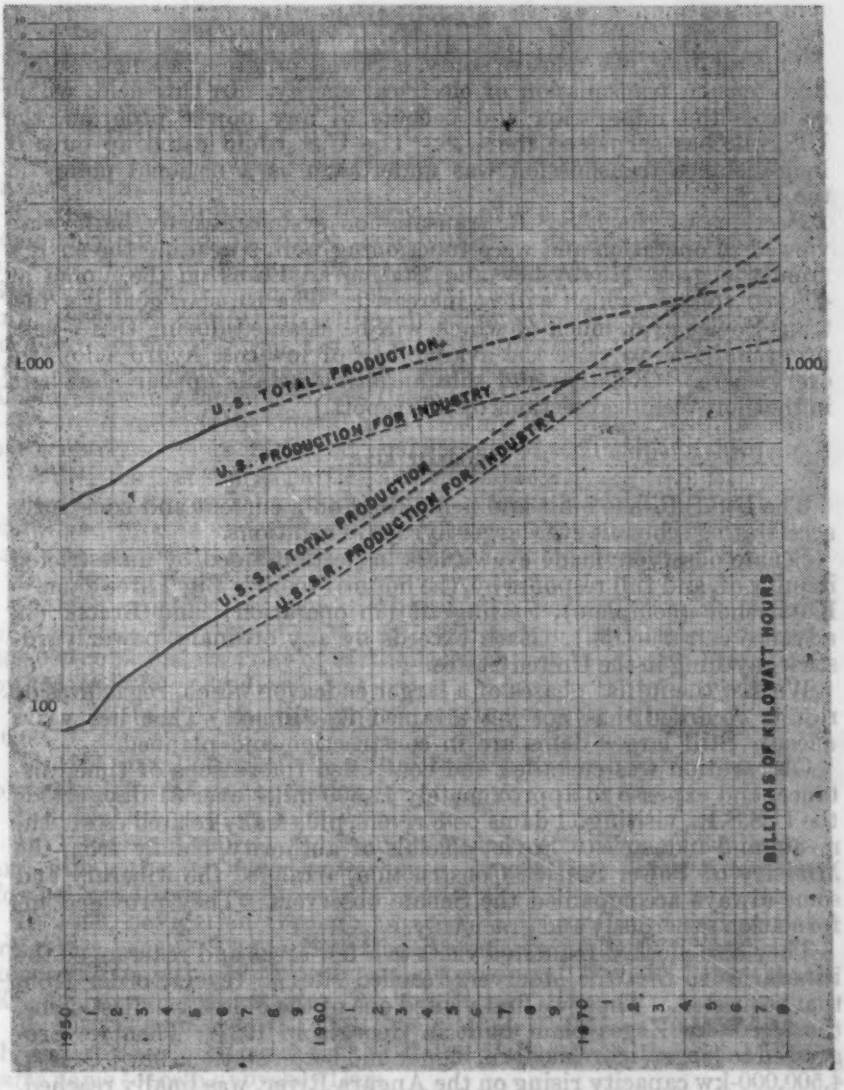
Everywhere in the U.S.S.R. people are urged to meet and beat their 7-year plan goals. Almost all graphs soar. This one, a popular number among the millions which dot the landscape, carries the message that the U.S.S.R. must lift its power production from 233 to from 500 to 520 billion kilowatt-hours by 1965.

perience has devoted a lifetime to this general field and is an outstanding recognized authority. He had the advantage of his own observations while traveling all over the Soviet Union as a consultant to the Senate committee—at his own expense. He has designed private and public power systems. He is considered disinterested personally. For a double decade he has enjoyed professional and congressional confidence, frequently being called as a witness and adviser on controversial power matters.

Under date of November 3, 1959, he advised the Senate committee:

> * * * I have now arrived at some results which appear to be reasonable to me. These are shown by four curves on the enclosed graph sheet and cover the total production in each country and the portion of the total production ostensibly devoted to industry.
>
> In making this comparison I have assumed that all of U.S. production, except that for residential, rural, and railroads and railways, is classed as production for industry. This is the only way I can see to get a direct comparison with Russian figures which apparently so classify their electrical production. Under this assumption the percentage of U.S. production used for industry becomes 68 percent as compared to Russia's 80 percent.
>
> Figures for U.S.S.R. total production were taken from the Federal Power Commission's "World Power Data Report" of July 1958. Total production projected for years beyond 1965 has been taken at the same compounded annual percentage increase as from 1957 to 1965. I note that Philip Sporn in his article in the Electrical World of November 2, 1959, suggests that the rate of growth in the U.S.S.R. will probably decrease in near future years. Others might also argue this, but I feel that Russia is now in a position somewhat corresponding to the position of the United States in the 1930's and may very well continue its presently predicted rate of growth through a period of at least another 20 years.
>
> The figures for U.S.S.R. production for industry have been taken as 80 percent of the total production figures.
>
> The figures from 1950 through 1957 were taken from the same source as the U.S.S.R. total production figures. The figures for years later than 1957 were taken from page 35 of the Federal Power Commission's 37th Annual Report, 1957, with a flat addition of 90 billion kilowatt-hours per year to cover energy generated by industries and energy imported. The next to last paragraph on page 34 shows the basis for this assumption.
>
> The U.S. production estimated to be used in industry has been taken as 68 percent of the total production figures for years subsequent to 1957.
>
> From the graph opposite you will notice that with the above assumptions the U.S.S.R. would pass the total production in the U.S. about 1975. The production for industry would be expected to pass that of the U.S. about 1973. * * *

Russia has 10 percent of the world's kilowatt hydropower potential, of which a bare one-thirtieth is installed. Relatively, the United States has less than one-third of the Russian potential, but we have



triple the installed capacity of the U.S.S.R. While this report, by Senate resolution, is directed primarily to "relative river development," it is informative to note that both nations have achieved approximately the same high ratio of thermal power development relative to hydro, with the United States installed thermal kilowattage tripling that of the U.S.S.R.

TRANSMISSION

Outstanding, in a relative study, is Soviet progress in long-distance high-tension transmission of electrical energy. In this field, which controls the integration and benefits of any power program, the U.S.S.R. has surpassed the U.S. The U.S. could catch up only if long-distance transmission was undertaken as a national policy in the U.S.

Sections of the U.S.S.R. transmission system already built were viewed in operation and were functioning well, spreading the energy from the great Kuybyshev and Stalingrad Dams on the Volga at 400,000 voltage, which will be increased. The Russian goal is a full trans-Soviet grid, much of which will be attained during this 7-year program so as to raise the availability of low-cost hydro kilowatts everywhere. (Relative and substantiating details appear elsewhere in the more technical sections of this report.)

PROJECT SIZE

The U.S.S.R. has built and is building on a current and constantly accelerating schedule ever larger hyropower stations.

Senate observers made eyewitness inspection aided by unrestricted inquiry of, and full response by, the hosts of today's Big Three dams—Kuybyshev (complete), Stalingrad (in operation), and Bratsk (in advance construction). Each exceeds by any ordinary power yardstick anything in the United States.

We saw the initial phases of a larger endeavor which, regardless of results recorded, has not yet attained its climax. That lies years ahead. Still larger dams are in construction and planned.

Observation was curtailed and controlled for reasons of time, distance, and expense to approximately 12,500 miles over 31 days inside the U.S.S.R., visiting 11 dams on 8 rivers, plus many related establishments and industries. Soviet officials of authority, chiefly from the Ministry of Power Station Construction, arranged the itinerary and some always accompanied the Senate observers. They provided information generously and graciously.

They also blocked requested visits to a few areas and rearranged the itineraries so that the observers reached sites in reverse order from that requested. Thus, we first visited one of the oldest, smallest dams, the 36,800-kw Zages plant built in Georgia in 1927. Then we progressed to larger, more modern, bigger and better stations until Bratsk, 4,500,000-kw capacity rising on the Angara River, was finally reached.

In this carefully prearranged and dramatized parade of progress through the Soviet projects, the point where the U.S.S.R. surpassed the U.S.A. in any relative comparison involving scope, velocity, and size, came on the Volga when we encountered Kuybyshev Dam.

KUYBYSHEV

Kuybyshev Dam, entirely completed with total generation of 2.3 million kw installed and operating, is the pride of the Soviet builders and, on a power-producing-capacity basis, the largest dam in the world.

It took that title from the U.S.A., which led the world for many years, first with Hoover Dam and more recently with Grand Coulee on the Columbia River.

Kuybyshev is outstanding by any one of the dozen-odd yardsticks commonly applied by world dam builders. It was conceived and undertaken as a dramatic symbol and proclamation of what the Soviet Government could do in this field. It was born with a priority on any materials, equipment, skills, or labor Russian resources could supply. Its erection was a highly successful command performance from the groundbreaking to its dedication in 1958 by Premier Khrushchev in a ritual that was the equivalent of a national festival.

By any standards the timetable on creating Kuybyshev was fast, and particularly so for an initial national venture of such scope in this field.

In 1949 the first survey parties checked the area.

In 1950 (August) the undertaking was authorized, a relatively simplified process under Soviet procedures. Preliminary access road and city construction started. Engineers started drawing the plans.

In 1952, work on the main dam structure began.

In 1953 and 1954, erection continued with some 1,900 cubic meters of concrete a day poured on the spillway and powerhouse section and 300,000 cubic meters a day of earth placements on the river dike section by dozens of huge dredges.

In 1953 and 1954, Kuybyshev maximum employment reached 16,000.

In 1955 installation of the initial turbine and generator was completed and it went into operation.

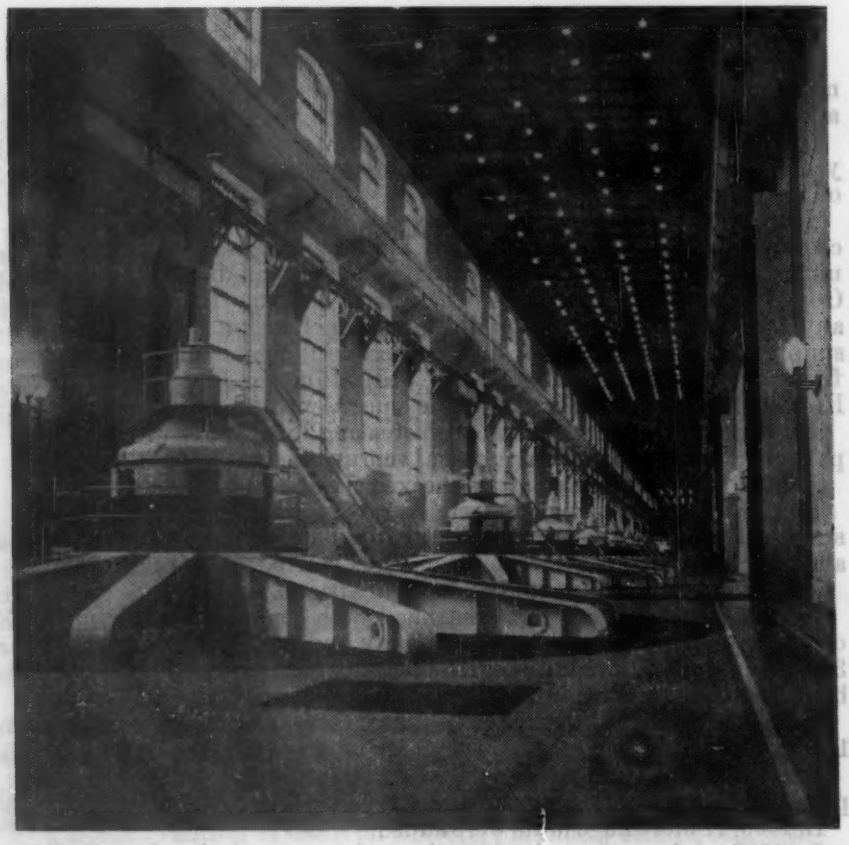
In 1956, 11 more huge units were added.

In 1957, eight more units went into place, completing installation and filling the 700-meter powerhouse—longer than seven American football gridirons.

In 1958, navigation through two-step locks continued and initial irrigation began. The Soviets staged a celebration with Khrushchev keynoting, pointing with pride, and promising all Soviet Citizens that Kuybyshev was just a starter.

In 1959 (October 6) the U.S. Senate observers drove 70 kilometers through an early blizzard up the Volga Valley from the city of the same name to see Kuybyshev Dam.

Chief Engineer Michael Sarkisov proudly led the Senate observers out on the floor of the biggest powerplant of the world, all 20 machines were spinning. Each, the Soviet bureaucrat said, was a 115,000 generator (the biggest) linked by a thick shaft to a Kaplan-type turbine underneath with 9.3-meter diameter runner (the biggest) that was whirled at 68.2 rpm by harnessed Volga River falling on it under an average head of 19 meters.



Kuybyshev powerhouse—biggest in the U.S.S.R. and the world today. These 20 generator units in a line, Russian-made, were all spinning when the Senate observers entered the 700-meter structure on the Volga River.

In the control room the dispatcher watched dials registering power flowing at 430,000 voltage (highest) to the Moscow area and also eastward to the Ural industrial complex over 1,000 kilometer lines (longest) that form the first legs of the trans-Soviet grid.

That morning the meters registered a cumulative Kuybyshev production of some 27 billion kilowatt-hours to date for power-hungry Soviet industry in its "peaceful war of production" to overtake and surpass the United States.

Kuybyshev, which can be considered a postwar second-half kickoff in a lengthening international competition, is but an incident in the overall development of the Kama and Volga Rivers system in western Russia, which system in turn is but a medium-sized incident among the nation's greater river system. All current Soviet river development planning is on the principle of eventual development of the full potential of the streams by terracing them with dams backing up reservoirs

to the toe of the next upstream dam in what is frequently called the cascade system. Any planning that forecloses reaping the full potential benefits is currently rejected in the U.S.S.R. as "incorrect," as, for example, the recent and rare direct Soviet criticism of the United States for failure at Hells Canyon to develop the full potential of the Columbia-Snake River system.

On the Kama (a northern tributary of the Volga) the Soviets plan 9 hydro stations and on the Volga itself, 13 power stations of which Kuybyshev Dam happens to be the fourth step of the terrace from the bottom—the mouth of the Volga where it flows into the Caspian Sea.

STALINGRAD

A 2-hour-and-15-minute southwesterly flight from Kuybyshev brings one to Stalingrad, Soviet wartime "hero city" and the next and newest development downstream of the Volga terracing. Virtually in the city, Stalingrad Dam was inspected October 4 by the Senate observers.

This giant, already functioning, has been driven a year ahead of the 7-year plan construction schedule. Upon completion in 1961 it will wrest the title of world's largest hydroelectric station from Kuybyshev—to hold it but briefly until a number of larger Siberian dams already underway are completed.

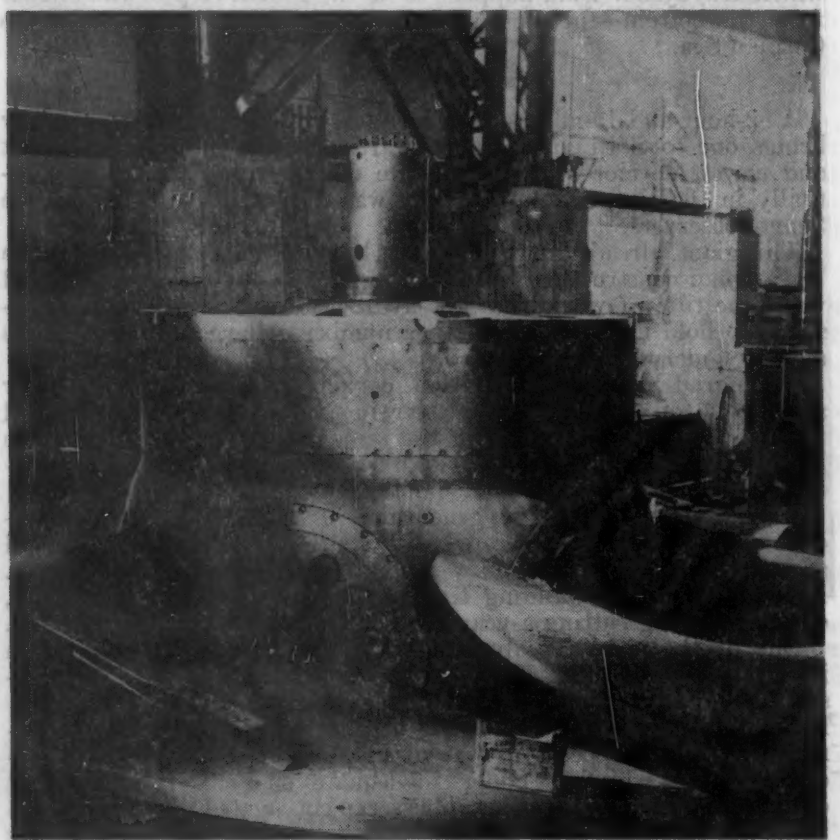
Stalingrad hydroelectric station, capacity 2,530,000 kw, naturally and wisely (on the same Volga River, in similar topography, designed for like purpose, and utilizing the same water) is very similar to its upstream neighbor and elder brother, Kuybyshev. Differences reflect a Soviet determination to do more in less time.

Stalingrad will have 22 generators—2 more than Kuybyshev—each the same size and operated with a slightly higher head to yield a project total of 230,000 kw more than the upstream structure. Everything learned building Kuybyshev was applied at Stalingrad, one result being cutting a year off the "crash" construction schedule.

One of the more revealing sights at Stalingrad was generation installation procedure. Three of the new generators had been installed and started operating before a roof was put on the powerhouse. So intense was the Soviet urgency to pass the kilowatt ammunition for the "peaceful war of production" that the three generators were whirling under inadequate shelters, fashioned out of discarded lumber, tar paper, plus scrap corrugated iron and secondhand tinplate picked up around the construction site. If this was unusual treatment for the initial three of the day's "largest generators in the world," it was identical with the fate of five more generators so installed and temporarily sheltered which were not yet in operation when viewed. The chief construction engineer, Alexander Alexandrov, said they would get around to putting a roof on the powerhouse when the crews had time.

This, and other such procedures inherent in putting the about-to-be world's largest hydro station into operation, 3 years before it was complete, gave the whole enormous construction job a sloppy appearance. One experienced inspector doubted if anybody could estimate within 2,000 tons how much unclassified, valuable, assorted metal scrap was lying around the huge construction area half buried

in mud. But the engineering appeared able and the construction sound. Volga River traffic and big timber rafts were being locked through unfinished navigation facilities. Fishways were unfinished and not functioning. Hardly a start had been made on the work to irrigate some 2.5 million acres of land by gravity out of the half-filled reservoir. It was evident that the No. 1 Soviet criterion of getting the most kilowatts on the line soonest to lift Soviet production, was being served at all costs.



This type of Kaplan hydro-turbine runner spins the kilowatts out of many Russian rivers. It awaits installation at Stalingrad Dam where Volga water falling at 26 meters head will turn it. Attached 115,000 kw generators, at 68.2 rpm, will make Stalingrad Dam the world's biggest power producer in 1960.

In the case of Stalingrad station, which alone will have capacity to produce 10 times the total kilowatt-hours Russia had in 1913, the power is going or will go on three transmission lines. One is a 220,000-volt line running southward. Another is a 500,000-volt line heading for Moscow. Another is a 700,000-line (operated on direct current) to the Donbas industrial coal basin. All eventually are to be linked into the trans-Soviet grid.

BRATSK

Siberia, with enormous rivers plus vast and still incompletely inventoried natural resources, is where the Soviets count on winning "the peaceful war of production" waged against the United States of America.

Bratsk hydroelectric station on the distant Angara River, inspected October 10 by the Senate observers, is in scope, velocity, and size without precedent, but is only a symbol of things to come in Siberia.

In prospect are Krasnoyarsk Dam, where construction started months ago and which has attained the cofferdam stage, the middle Yenisey Dam, the lower Ob' Dam, and many others, large and small, under construction, completely planned or merely surveyed. Soviet officials uniformly reject any idea that they will not be built. In support of this view they simply cite their conviction that all are essential because the best electrified economy must be the victor in the battle of production.

Bratsk, eyewitnessed as somewhat less than half finished with the river closed off, is designed as a power producer of 4.5 million kilowatts approximately doubling on most scores any project anywhere at any time. Running somewhat ahead of a schedule on which construction started in 1955 with first-unit generation due in 1961, Bratsk, upon completion in 1963, will take its turn as "world's biggest"—and then be over taken and surpassed by Krasnoyarsk in the kilowatt kaleidescope sweepstakes.

Now ordered for Bratsk (and being fabricated with none delivered or needed yet) are 20 generator units of 225,000-kw capacity—each the largest yet. (At Grand Coulee for about a decade 18 generators of 108,000-kw nameplate capacity have been spinning to yield some 10 percent beyond guaranteed rating.) Bratsk generators will be whirled by Francis-type turbines under 102 meter head.

Chief Engineer Aron M. Gindin, accompanied by his top staff, proudly and politely escorted the Senate observers over the Soviets' pride, pointing out multiple construction features. For a long day he directly and specifically answered anybody's questions pertinent to the job. Bratsk is in a remote forest. A railroad, highway, saw mills, and a power line have been built, along with a workers' city which will be improved to become a permanent industrial complex.

Chief Engineer Gindin said his crews were dedicated Communists from all over the Union of Socialist Soviet Republics. They call themselves pioneers and have been led to feel honored to serve as paid shock troops of their country's construction drive at Bratsk. Some appeared more dedicated and energetic than experienced. While the Senate observers watched, a contingent of 73 sailors in Russian Navy uniforms walked down a muddy road into camp from a pair of stalled buses. Inquiry brought the explanation they had recently finished their naval service and decided to proceed directly to Bratsk, a nearly womanless establishment, because they wanted to help build the dam. This, if true, establishes some sort of precedent for both naval and construction affairs. The chief engineer was about the only big construction boss ever found anywhere who did not complain of a manpower shortage to accomplish his task. At the moment he had 14,000 workers on his payroll. This he described as "peak" employment and "at least all I can give beds and roofs."

Bratsk, as a construction job, is outstanding for its enormous size. It is rising with the aid of large modern equipment in the form of modern huge dredges, draglines, shovels, cranes, trestleways, cableways, steel bridgework, carryalls, concrete batching plants, all manner of wheeled and tracked conveyance, forges and shops, and could use more. All over the site is evidence of the Soviet concentration on the time element at some sacrifice to other basic construction factors, including economy, simplicity, and ease.

Bratsk is being driven to completion as a big gun in the "war of production" around-the-clock and around-the-calendar. Floodlight towers all over the job physically established, as the builders boasted, that the crews were triple shifted on a 24-hour basis. An assortment of heating devices showed how hot pours of concrete were made through the zero and sub-zero Siberian winter months. The engineering, supervision and construction, appraised on the basis of finished work, appeared both bold and of high standard.

At Bratsk, less than half completed when viewed and listed as a 7-year job in parts of two 7-year plans, the Senate observers were told the works in place were already 2 years ahead of schedule. Without disparagement of the obvious high national velocity of the construction, those observers who are familiar as prior practitioners with the techniques of such timetable scorekeeping deduced there is a factor of built-in leeway in the Soviet 5- and 7-year plan schedules. While these plans, as to dams, are generally unveiled as embracing what Americans may consider an all-out crash concept, it is not impossible they provide periods for some normal fumbling and delays inherent in the hazards of giant construction. Such practice provides insurance that goal or target dates of completion are attained or even anticipated. The foresighted and wise administrator in this field, who knows the local or national capabilities better than any foreigners, is likely to insert early the greatest time safety factor to insure success into the huge jobs that command the widest world attention. While the whole Soviet river development program is proceeding with acknowledged dispatch and display of great professional capability, the probability of built-in leeway in the 7-year plan schedules is not denied by the record. Successively, on the three giant dams that in turn became the largest in the world, Kuybyshev was completed near proclaimed schedule; Stalingrad, already in operation but unfinished, is currently reported a year ahead of schedule, and Bratsk, barely half done, is described as 2 years ahead of schedule.

THE BAIKAL-ANGARA-YENISEY COMPLEX

At Bratsk the Soviets are convinced they have the best opportunity man has yet seized to produce the cheapest electrical energy. This is due to the unique natural phenomenon of Lake Baikal and the Angara and Yenisey Rivers. It is here summarized with a few figures as responsive to the Senate resolution requiring a relative study of U.S.S.R.-U.S. river development.

Lake Baikal, visited by the Senate observers October 11, lies deep in Siberia just north of Outer Mongolia, and comprises the greatest mass of fresh water on the Asian Continent. Relatively its water volume exceeds that of the five Great Lakes of North America, Superior,

Michigan, Huron, Erie and Ontario combined. Into Lake Baikal, which is more than 1,700 meters deep, flow 336 separate streams. Only one, the swift, high rock-walled Angara River, flows from the lake, northwestward, eventually to join the Yenisey and continue thousands of miles onward to the Arctic Ocean.

The topography is such that for each vertical meter of elevation control works established on the Angara River outlet, 31 billion cubic meters of controlled storage is backed up in Lake Baikal. This is a natural hydrological payout without precedent. In relative and comparable terms it is in the nature of achieving vital and essential storage in the range of Lake Mead, long the largest manmade body of water anywhere, by building a 1-meter dam instead of the 700-foot Hoover Dam that backs up the Colorado River to form Lake Mead.

The Soviets have plugged the Angara with Irkutsk Dam, completed in 1958 and visited by the Senate observers October 12, not with a single meter barricade but with a great structure providing 30 meter head. As an interim incident to the principal purpose of Irkutsk Dam, which is to secure the vast Baikal controlled storage for repeated use in all downstream hydroelectric developments, the Soviets dropped eight turbine generating units into Irkutsk giving it an installed capacity of 660,000 kw—considerably exceeding Shasta Dam in California. The resultant 4.1 billion kilowatt-hours production was used forthwith for industry in and near the city of Irkutsk, Bratsk construction, the electrified Trans-Siberian Railroad and other purposes.

There is a drop of 378 meters in the Angara between Baikal Lake or reservoir and the river's confluence with the Yenisey of which it is one tributary. The Soviet planning policy uniformly requires development of the full electric potential. Irkutsk Dam, completed, and Bratsk, advanced, only utilize 132 meters or about one-third of this drop. Therefore plans have been drawn for six hydro stations terracing this stretch of the tributary yielding a total 14 million kw installed capacity. All Baikal storage, as augmented by intervening dams and reservoirs, will also be utilized along the thousands of miles of Yenisey mainstream en route toward the Arctic Ocean and the North Pole. The Senate observers did not tarry to collect capacity figures on this stretch, for the Russians have not completed this study. They are happy, however, to recite about one fine site called the Upper Yenisey. There plans are already advanced to a blueprint stage that has elevated it in the Soviet future, after this 7-year plan, to the status of another "world's largest"—with no construction started or firm date therefor heralded. Pravda has reported that this project will be begun in 6 or 7 years.

SOVIET TECHNOLOGY

Soviet engineers are capable. A 13-year span is embraced in the era between the start of Kuybyshev and the scheduled completion of Bratsk. During that period their ranks were augmented by a host of technicians poured forth from various technical schools, universities, institutes, academies, and other educational centers of high quality acknowledged to exceed, in size, similar graduating groups in the United States. For over a dozen years the early leaders, the cream of the dam-building craft have been shuttled from job to job inside and outside Russia acquiring practical experience, and what is frequently

termed "know-how," that is now being reflected in dam completion celebrations.

Thus, the world is entering an era of exposure to ceremony in the U.S.S.R., emphasizing the success and achievement of Asian power dam erection together with the economic and production attainments dependent thereon.

HYDROELECTRIC DEVELOPMENT IN THE SOVIET POWER SYSTEM

(By M. C. Mapes, Jr.)

Lenin, being a true Marxist, rejects all utopians. At last he himself has succumbed to a utopia, the utopia of electrification.

He is exerting every effort he can with a view to creating in Russia big electric power stations which will supply electric power to whole regions for light, transport, and industry . . . Can one imagine a bolder plan than this program—in that flat country covered with forests, populated by illiterate peasants, deprived of sources of water energy, lacking technically trained people and where trade and industry are nearly extinct!—HERBERT WELLS, "Russia in the Shadows" (1920), quoted by Nikita Khrushchev at the dedication of Kuybyshev Hydroelectric Station, August 10, 1958.

One of the first questions which must be answered for the purposes of any study of Russian hydroelectric development is: What is the place of hydropower in the power system of the U.S.S.R.—past, present, and future? Corollary to this, in the context of recent discussion of this very problem, is the question of whether or not there has been a "downgrading" of hydroelectric development by the Soviet planners, and, if so, why? On the other hand, if not, what is the explanation of the difference between the fact and the widely held view that such a downgrading has been put into effect?

In answering these questions every effort will be made to avoid becoming entangled in any purely semantic exercise revolving around the question of the "downgrading" of Soviet hydro development; I shall attempt to present the facts to the extent they are presently available, state a few conclusions based on those facts, and suggest what the probable course of hydroelectric development may be during the next decade or so in the Soviet Union.

WHAT IS THE SOVIET UNION'S HYDROELECTRIC POTENTIAL?

The question of the actual usable potential in the rivers of Russia is somewhat difficult to answer positively because the Soviet engineers themselves seem to use a variety of figures, often without defining very clearly what they comprise, and the terms "theoretical potential," "technical potential," and "economic potential" have been used (and translated) somewhat carelessly. The facts seem to be approximately as follows:

Shortly after the end of World War II the Soviet Union conducted an extensive survey of its water resources, the most complete in its history. The conclusion of this survey, as published in 1950, was that on the 1,477 rivers surveyed there was a theoretical hydroelectric potential of 340 million kilowatts of installed capacity. Assuming an average plant factor of about 58 percent, this capacity would produce slightly over 1.7 trillion kilowatt-hours per year; these

two figures are the ones most widely used as being Russia's total hydro potential. Actually, the Soviet engineers add another 80 million kilowatts as an estimate of the potential of certain far eastern rivers omitted from the original survey, for a national theoretical total of 420 million kilowats.

Of the figure of 1.7 trillion kilowatt-hours obtained in this way, it was estimated that 1.2 trillion would be developed at large regional or interregional projects which would be "industrially significant." It should be noted that such phraseology does not constitute a finding of economic or even technical feasibility, although the 1.2 trillion figure is widely used in such contexts.

However, in the 1950 study were included 1,850 projects on which at least preliminary planning had been done, and the annual output of these projects was estimated to be approximately 586 billion kilowatt-hours. This is the closest thing to a firm figure available at present. Thus we can safely say that 1958's hydroelectric production of 46 billion kilowatt-hours was slightly less than 8 percent of the known and planned potential and probably over 4 percent of the total ultimate potential, assuming the firm figure to be too conservative by almost half. Such an assumption is probably justified when talking of "ultimates" because of the possibility that projects not presently desirable could become quite feasible when considered at some future date as a source of peaking power for a largely thermal—or atomic-powered system. And further study will undoubtedly discover a considerable number of projects not included in the initial survey.

In terms of our present discussion of hydro's place in the Soviet power system we can summarize these findings as follows: In addition to projects already completed there are at present readily available in the Soviet Union sites for hydroelectric projects with a total annual potential of almost 550 billion kilowatt-hours, substantially more than the total national production planned for the year 1965. Thus, if the proportion of hydro in the Soviet power system remains at its present level of about 20 percent, and if that system continues to increase its total production at a rate of about 10 percent per year, there will be plenty of hydro resources available to keep the Russian engineers happily occupied for at least the next 20 years.

FULL DEVELOPMENT THE SOVIET GOAL

We were informed that the goal of Soviet multipurpose hydro development is "the full potential development of the river." The method of achieving this was described as follows: First the overall national plan for water resource development is drawn (apparently a reference to the 1946–50 study). Then the plan for the full utilization of any river to be developed is worked out in preliminary form, including such features as upstream storage, river regulation, navigation, and power development.

With such preliminary plans in hand, Gosplan then assigns specific projects for detailed local investigation, and chooses the projects to be included in any 5- or 7-year plan on a national basis, presumably on the advice and recommendation of the regional economic councils, as described in another report on the Soviet organization for power supply. Normally the most economic projects will be chosen for

first development, with consideration given to the desirability of storage projects for river control; flood control is given consideration, although it is not nearly as important as in some other countries. Changes in plans once drawn are made according to their importance—very small changes on the job by the chief of construction, larger changes by the local planning and research institutes, and major modifications by Gosplan in Moscow, presumably with the assistance of the two planning and research institutes of the Ministry of Power Station Construction.

The devotion to the concept of full development by the Soviet engineers was emphasized by a question which came up during the discussion of the procedure for changing plans once prepared. The question was whether a plan for the full development of any river basin would be changed to permit a lesser development scheme which would achieve a more "economic" result; it created such confusion in the reaction of the Soviet engineers, who obviously found it unthinkable, that it finally had to be withdrawn.

WHAT PART HAS SOVIET HYDRO DEVELOPMENT PLAYED IN THE PAST?

In order to obtain perspective on the part which hydroelectric power is to play in the future development of the Soviet power system it is necessary to examine its function in the past. Even a cursory examination of the relevant statistics can lead to only one conclusion—that hydropower has been gradually increasing in importance in the Soviet system since its beginning. The figures for the percentages of hydro in terms of both installed capacity and total annual energy production are shown in the following table taken from official Soviet sources:

Percentages of hydroelectric power in the power system of the U.S.S.R., 1913–58

Year	Installed capacity	Annual energy	Year	Installed capacity	Annual energy
1913	1.5	1.8	1950	16.4	13.9
1925	1.9	1.4	1951	15.1	13.2
1930	4.5	6.5	1952	15.1	12.5
1935	12.9	14.0	1953	15.8	14.3
1940	14.2	10.6	1954	15.6	12.3
1945	11.3	11.1	1955	16.1	13.6
1946	11.6	12.4	1956	19.5	15.1
1947	13.0	12.9	1957	20.7	18.9
1948	14.5	14.1	1958	20.3	19.9
1949	16.3	14.7			

Source: "Electric Power Engineering in the U.S.S.R., 1958."

SOVIET HYDROELECTRIC DEVELOPMENT IN THE FUTURE

As the previous table demonstrates, the proportion of hydroelectric energy in the Soviet power system has grown fairly consistently to its present level of just about 20 percent. To give a more complete picture of the energy balance in that system the following table presents the fuel balance as estimated in 1958 and projected for 1965; as indicated, the major change is the increased use of petroleum and natural gas for the generation of power and the dropping off in the proportion of coal-fired plants in the system. The percentage of hydro is expected to change not at all.

Fuel balance in the electric power system of the U.S.S.R.

[Percentages of total energy production]

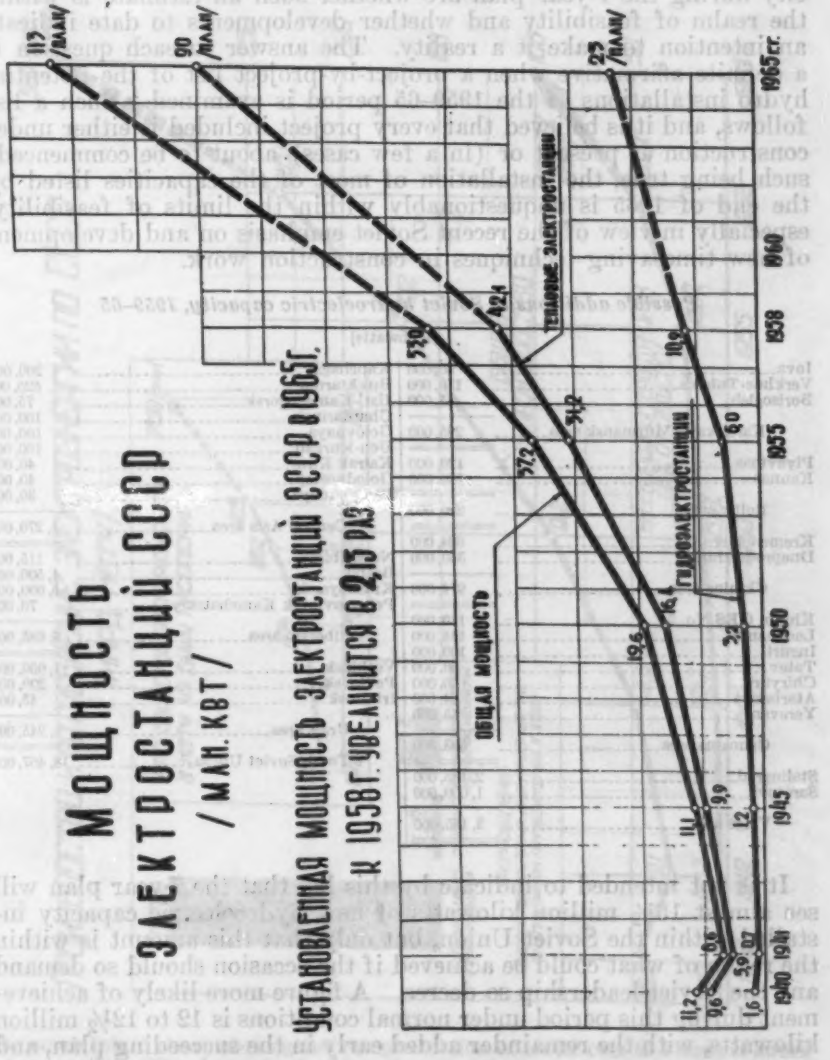
Energy source	1958	1965
Coal	57	47
Water	20	20
Peat	7	5
Natural gas	9	14
Petroleum	5	12
Other	2	2

During our conferences we were informed by Power Ministry officials in Moscow that they considered the present 4 to 1 ratio of thermal power to hydro just about right, and that having attained that proportion they expected to maintain it for some time in the future. Specifically, we were told that during the 7-year plan their plans called for the installation of 58 to 60 million killowatts of new capacity and that about 12 million of this would be hydroelectric capacity. This was more definite than some of the public statements which had been reported previously, since those statements estimated merely that "over 10 million kilowatts" of new hydro capacity would be included in the 1959–65 schedule.

The Ministry also provided us with two graphical representations of the growth of the Soviet electric system entitled "Installed Capacity of Electric Power Stations in the U.S.S.R." and "Production and Consumption of Electric Energy in the U.S.S.R." The two graphs which appear are included because of their relevance to the subject under discussion. As a brief examination of them will make apparent, the first one indicates a 7-year plan increase in installed hydro capacity from 10.9 million kilowatts (20.6 percent) to 23 million kilowatts (20.4 percent), or just over 12 million kilowatts. The second one indicates an increase in annual production of hydroelectric energy from about 46 billion kilowatt-hours to about 100, and the graph specifically labels these two amounts as being 20 percent of each year's total production.

INSTALLED CAPACITY OF ELECTRIC PLANTS IN THE U.S.S.R.

[Millions of kilowatts]



The subtitle of the above chart states that installed capacity of electric stations in the Soviet Union in 1965 will increase to 2.13 times the 1958 figure. The top line is total installed capacity, the middle line thermal electric capacity, and the bottom line hydroelectric capacity.

The two questions which are immediately raised by this estimate of an additional 12 million kilowatts of installed hydroelectric capacity during the 7-year plan are whether such an estimate is within the realm of feasibility and whether developments to date indicate an intention to make it a reality. The answer to each question is a definite affirmative when a project-by-project list of the potential hydro installations of the 1959–65 period is examined. Such a list follows, and it is believed that every project included is either under construction at present or (in a few cases) about to be commenced; such being true, the installation of most of the capacities listed by the end of 1965 is unquestionably within the limits of feasibility, especially in view of the recent Soviet emphasis on and development of new timesaving techniques in construction work.

Possible additions to Soviet hydroelectric capacity, 1959–65

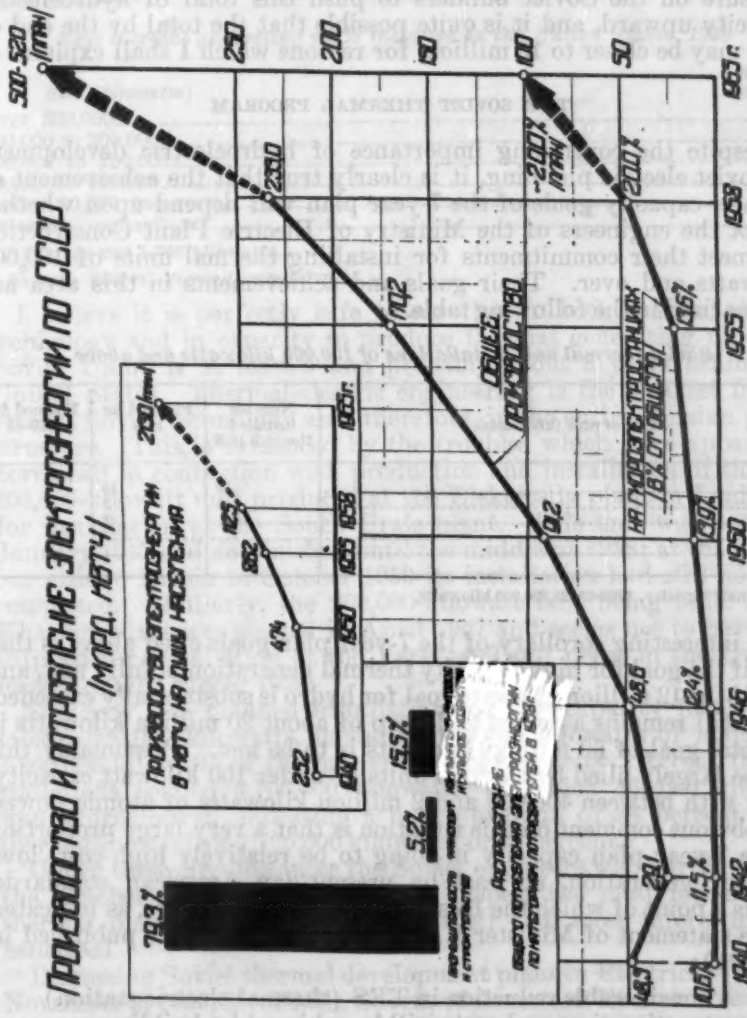
[Kilowatts]

Iova	80,000
Verkhne-Tuloma	170,000
Borisoglеb	45,000
Karelskaya-Murmansk area	295,000
Plyavinas	120,000
Kaunas	100,000
Baltic area	220,000
Kremenchug	624,000
Dneproderzhinsk	350,000
Ukraine area	974,000
Khram GES No. 2	110,000
Ladzhanuri	144,000
Inguri	100,000
Tatev	50,000
Chiryurt	60,000
Atarbekya	84,000
Yerevan	45,000
Caucasus area	593,000
Stalingrad	2,185,000
Saratov	1,000,000
Volga area	3,185,000
Kapchagay	200,000
Bukhtarma	525,000
Ust' Kamenogorsk	75,000
Chardarinsk	100,000
Golovnaya	100,000
Ucb-Kurgan	160,000
Kairak Kum	40,000
Golodnostep	40,000
Perepadnaya	30,000
Central Asia area	1,270,000
Novosibirsk	115,000
Bratsk	4,500,000
Krasnoyarsk	5,000,000
Petropavlovsk Kamchatskiy	70,000
Siberian area	9,685,000
Votkinsk	1,000,000
Pavlovsk	200,000
Iriklinsk	45,000
Urals area	1,245,000
Total, Soviet Union	18,467,000

It is not intended to indicate by this list that the 7-year plan will see almost 15½ million kilowatts of new hydroelectric capacity installed within the Soviet Union, but only that this amount is within the realm of what could be achieved if the occasion should so demand and the Soviet leadership so decree. A figure more likely of achievement during this period under normal conditions is 12 to 12½ million kilowatts, with the remainder added early in the succeeding plan, and

PRODUCTION AND CONSUMPTION OF ELECTRIC ENERGY IN THE U.S.S.R.

[Billions of kilowatt-hours]



The small inlaid chart above gives the production of electricity in kilowatt-hours per capita. The bar chart gives the distribution of all consumption of electricity by category of consumer in 1958, the three categories being industry and construction, transport and residential, community service [residential] and agricultural, from left to right. The top line on the main chart gives the total annual energy production and the lower line gives hydroelectric energy production.

this we shall likely see. However, it is my own very strong opinion that toward the end of the 7-year plan there is going to be immense pressure on the Soviet builders to push this total of hydroelectric capacity upward, and it is quite possible that the total by the end of 1965 may be closer to 15 million, for reasons which I shall explain.

THE SOVIET THERMAL PROGRAM

Despite the continuing importance of hydroelectric development in Soviet electric planning, it is clearly true that the achievement of the new-capacity goals of the 7-year plan will depend upon whether or not the engineers of the Ministry of Electric Plant Construction can meet their commitments for installing thermal units of 100,000 kilowatts and over. Their goals and achievements in this area are summarized in the following table.

Soviet thermal unit installations of 100,000 kilowatts and above

Size of unit (kilowatts)	Number installed through 1958	Planned for 1959	Planned for 1959–65
100,000	59	15	46
150,000	5	3	27
200,000		1	38
300,000			28
600,000			2

Total new capacity, 1959–65, 25,850,000 kilowatts.

An interesting corollary of the 7-year plan goals cited above is that even if the goal for high-capacity thermal generation is fully met, and even if the 12 million kilowatt goal for hydro is substantially exceeded, there still remains a very sizable gap of about 20 million kilowatts if the total goal of 60 million kilowatts is to be met. Presumably this will be largely filled by thermal units of under 100 kilowatt capacity, along with between 400,000 and 2 million kilowatts of atomic power. The obvious comment on this situation is that a very large proportion of the 7-year plan capacity is going to be relatively high-cost, low-efficiency generation, at least by present-day American standards. This is a point of which the Russians are perfectly aware, as indicated by the statement of Minister I. T. Novikov in an article published in May 1959:

> A considerable reduction in TES (thermal electric station) construction time and costs will be achieved by building condensing TES with extra large capacities. TES with capacities of 300,000–600,000 kilowatts and power units of 25,000–100,000 kilowatts can be built at a cost of 1,000–1,300 rubles per kilowatt of installed capacity, and TES with capacities of 1.2–2.4 million kilowatts with individual power units of 200,000–300,000 kilowatts can be built at a cost of 750–850 rubles per kilowatt.—"Construction of TES in 1959–1965," by I. T. Novikov in Teploenergetika, No. 5, 1959.

For comparative purposes the following table of all nonatomic thermal units newly installed in the United States during 1958 is included here:

New thermal generating units installed in the United States, 1958

Size (kilowatts)	Number of units
Over 300,000	3
200,000 to 300,000	10
100,000 to 200,000	42
50,000 to 100,000	16
Under 50,000 (steam)	49
Internal combustion	[1] 57

[1] Average size 1,706 kilowatts.

Source: Federal Power Commission.

I believe it is perfectly safe to say that in both thermal-electric technology and in capacity to produce thermal generating units the Soviet Union is at least 5 and probably about 8 years behind the United States. Thermal-electric engineering is the weakest link in present Soviet technology and, therefore, in the entire Russian power structure. This is evidenced by the troubles which have apparently developed in connection with production and installation of the first 200,000-kilowatt unit produced at the Elektrosila plant in Leningrad for installation at the South Urals plant. This unit was begun in January 1957 and not finished until the middle of 1958; at the time of our visit to Russia in October 1959 its installation had still not been completed. Similarly, the 200,000-kilowatt unit being built at the Kharkov plant was started in April 1957 and seems not to have been shipped for installation at the Verkhne Tagil plant in the Urals at least through October 1959.

Similarly, the planned installations of new capacity for 1958 totaled 5,600,000 kilowatts, including 640,000 kilowatts of hydro and 4,960,000 kilowatts of thermal and atomic capacity. Actual 1958 installations totaled 4,700,000 kilowatts, of which 860,000 kilowatts was hydroelectric, indicating a hydro overrun of 34 percent and a thermal shortfall of 1,120,000 kilowatts, or 23 percent.

Under these circumstances the Soviet engineers who participated in the October 1959 exchange visit to inspect the most modern U.S. thermal plants undoubtedly found their trip most interesting and beneficial.

Discussing Soviet thermal development plans in Electrical World of November 2, 1959, Mr. Philip Sporn, of American Electric Power Co., commented:

> The significant point about this aspect of the Russian program (inclusion in the 7-year plan of twenty-eight 300,000-kilowatt units) is neither size of unit nor steam temperature, but rather the supercritical pressure of 3,420 psia. Novikov does not disclose what experience is behind Russia's decision to build 28 plants in the supercritical pressure range.

I would go further than Mr. Sporn and estimate that this is an example of the Soviet planners making advance plans on the basis of a technology not yet achieved and demonstrated by their technicians. They may very well be able to carry out those plans, but in view of the

apparent difficulty experienced with the 200,000-kilowatt units it is worth noting that American planners, with six supercritical units either completed or under construction in this country, have temporarily drawn away from the supercritical pressure range in their advance planning to await further operating experience with these first units.

It would be a mistake to underestimate the ability of the Soviet engineers to cope with these difficulties, and it is not my intention to do so, but merely to point out that at present these difficulties appear to exist. The recent testimony of CIA Director Allen W. Dulles before the Joint Economic Committee of the Congress is worth noting in this connection:

> * * * Soviet performance on past plans, particularly postwar, has been relatively good. The fourth 5-year plan (1946–50) was fulfilled well ahead of schedule. The goals of the fifth 5-year plan were more than met.
>
> The sixth 5-year plan was abandoned early in its life. It soon was apparent that it was too ambitious. In contrast, the 7-year plan (1959–65) was more carefully drawn and is a reasonable blueprint of attainable growth. Experience teaches us that Soviet industrial plans should be taken seriously. * * *

It should be pointed out that it is perfectly possible for the Soviets to achieve their 1965 goal for annual energy production while falling considerably short of their installed capacity goals, if by more efficient use of their power resources and improvements in system integration they can improve their average plant factor, which in 1958 was barely 50 percent. They informed us their goal for total installed capacity for 1965 was 113 million kilowatts, which would presuppose a plant factor improvement to 52½ percent to produce their optimum energy goal of 520 billion kilowatt-hours per year. An improvement to 55 percent would permit them to achieve this goal with an installed capacity of only 108 million kilowatts, a figure which has sometimes been used in the past, and an improvement to 57 percent would permit them another 4 million kilowatt shortfall in capacity. Additionally, the way the energy goal is always stated is "500–520 billion kilowatt-hours," so any figure over the half-trillion mark will indicate complete success.

Nevertheless, it is of particular relevance to the subject of this report that, although the Soviets may be lagging considerably behind us in the field of thermal power technology, the same can certainly not be said of their hydro techniques. Not only are they leading the world in hydroelectric plant size, but they have at least two dozen of the world's largest hydro turbine-generator units now operating and expect to be installing units twice as large within 2 years and four times as large within 6 years—and there is no reason at all to believe such expectations will cause them any serious trouble in the accomplishment. They are presently at least our equals in hydro technology and, if we can judge by the work we saw in progress, are clearly leading the world in some of the techniques of hydro-project construction.

Under these conditions it would be more than surprising if the Russians did not rely heavily on their proven ability in the field of hydroelectric development in attempting to bring their 7-year plan goals

to full realization. In fact, it would require only a very minor holdup in their planned program for thermal development to create the greatest possible compensatory pressure on the hydro program, which could considerably increase the present estimate of 12–12½ million new hydroelectric kilowatts by 1965. In any event, it is safe to say that any drop in the proportion of hydroelectric generation in the Russian power supply structure in the next 7 years is highly improbable.

THE CONFUSION OVER THE "DOWNGRADING" OF HYDRO

The issue of whether or not hydroelectric power had been "downgraded" by Soviet planners arose as a result of Premier Krushchev's speech at the dedication of Kuybyshev Dam, August 10, 1958. In that address the Premier emphasized the importance of saving time and initial investment costs in the construction of powerplants to permit the U.S.S.R. to overtake the U.S. lead in productive capability, even if this meant higher cost power for the Sovet Union. He therefore proposed to arrest the development of some hydroplants to give priority to thermal construction, while not stopping the construction of hydro. In the interest of brevity a few short quotations from the Krushchev address which give the sense of his then-current views on this problem are included here:

> * * * the reduction of the time needed for building is of enormous significance for the national economy. * * * The reduction of time need for the building of power stations will enable us to speed up the solution of our main economic problem: To catch up with and surpass the leading capitalist countries in per capita production. * * *
>
> It is known that electric power is the cheapest that is generated by hydropower stations. Why? Because after completing the construction of the hydropower station and putting the turbines into operation, almost no human effort is needed. The main function of production control is carried out by automatic and telemechanical means. * * *
>
> Given present conditions, the main thing is to win time, to reduce the construction time, and to obtain more electric power with the least expense. At the same time, from the viewpoint of the state, it is expedient to accept deliberately a certain rise in kilowatt-hour costs with a view to winning time and to obtaining in a short span of time a maximum increase in the electric power output * * * we arrive at the conclusion that a present one has to arrest to some extent the development of the construction of some hydroelectric power stations in order to give priority for some years—maybe for 7 or 8 years—to the construction of the thermal power stations.
>
> This does not at all mean that one should cease the construction of hydropower stations. We do not contrast the construction of hydropower stations with that of thermal-power stations. The point at issue is to give priority to the construction of thermal-power stations, in view of winning time in the competition with capitalism, of catching up with and out-

> stripping the United States in the per capita output of the population. * * *
>
> If we increase the scale of building thermal-power stations, we will achieve a sharp increase in the output of electric power in a very short time. * * *
>
> The factor of time in this matter is more valuable than the direct material expenditure—because most time cannot be compensated for by any money.

The Premier also discussed the advantages of building gas-fired thermal plants instead of the hydroelectric plant at Saratov and coal-fired thermal plants at such locations as Krasnoyarsk and other Siberian sites, where cheap coal was available, and added that the construction of a series of hydropower stations would be delayed to some extent.

If no further study or surveillance were given to the Soviet hydro program, it would be logical to think that the Khrushchev August views would be Soviet policy for the next few years at least. Unfortunately, this would give a mistaken impression, because his views were subsequently revised and to some degree reversed after being taken under attack by such people as Strumilan, the 80-year-old dean of Soviet economists; this reversal was carried out completely without public announcement, and may have been partially due to a growing realization by the Russians of the problems facing them in their thermal-electric technology, as discussed earlier. In any event, Saratov is now under construction and is scheduled for completion within the 7-year plan; Krasnoyarsk is under construction, and we were advised that the initial 500,000-kilowatt units would be installed in 1965.[1] How many additional hydro plants have been as quietly slipped back into the program only additional time and study will show, but there can be little doubt that the status of the hydroelectric program has been considerably changed from what it was at the completion of the Khrushchev Kuybyshev speech.[2] Probably one reason for this, if an estimate of causes is permissible at this point, is the remarkable progress made by Soviet hydroelectric construction engineers in improving their construction techniques to reduce both costs and construction time.

In any event, by January 25, 1959, Tass, the Soviet news agency, could comment on the Pravda article by the new Minister of Power Station Construction that—

> Novikov stresses that the priority of thermal stations does not mean that the construction of hydropower stations has been given up. During the 7-year plan, over 10 million kilowatts—as against 7.4 million during the last 7 years—will be commissioned at such stations.

---

[1] This information, as well as several of the conclusions on Soviet scheduling of hydro installations has been reinforced since the drafting of this report. An article on p. 3 of Pravda of Oct. 20, 1959, discussed the acceleration of the construction schedule for Krasnoyarsk Dam under orders from Gosplan and Minister Novikov. Under this accelerated schedule the initial unit is expected to be installed in 1963–64.

[2] For a more complete discussion of this revision, the paper submitted by Dr. John P. Hardt of the Corporation for Economic and Industrial Research, Inc., and printed in preparation for the November 1959 hearings by the Joint Economic Committee on the subject, "Comparisons of the United States and Soviet Economies," is highly recommended.

And in his address to the 21st Congress of the Communist Party on February 2, 1959, Novikov added:

> Much work has been done in reviewing the plans for a number of very efficient hydroelectric powerplants needed for the national economy with a view to further reducing their cost. In the very near future we will be able to report to the Government and propose thrifty hydroelectric plants as realistic projects, with their construction beginning as early as in the course of the current 7-year period.

This would seem to indicate that there will be a continuing series of new starts begun as the construction of current projects is completed; this is in conformity with the practices which were described to us of moving a large proportion of the construction workers from each project when completed to new projects being begun.

In the area of construction costs we received much information to support the opinion expressed by Minister Novikov regarding the development of "thrifty" hydroelectric plants, particularly with reference to the great new projects planned on the rivers of Siberia. For example, we were told that although the capital investment costs on Kuybyshev had been approximately three times as high per installed kilowatt as a modern thermal plant, the mighty 7 million kilowatt Yenesey project and the 6 million kilowatt lower Ob project would require only about the same initial investment as new steam generation, and the 5 million kilowatt Krasnoyarsk project only a very small amount more.

It is also worth noting that the planned investment in power facilities for the 7-year plan provides strong evidence of the reduction in costs of hydroelectric development which is being achieved in Russia. Although the 7-year plan is expected to produce upward of 10 and probably of 12 million kilowatts of installed capacity, or perhaps half again as much as the 7.4 million kilowatts of the previous 7 years, the investment in hydro projects is expected to be barely half as large. In tabular form the comparison can be summarized thus:

Comparative investment in hydroelectric facilities

Period	Investment (billions of rubles)	Installed capacity (millions of kilowatts)
1952–58	36	7.4
1959–65	[1] 20	[2] 10–12.5

[1] Planned.
[2] Estimated.

CONCLUSIONS

1. The Soviet Union has within its borders immense hydroelectric resources, which it is proceeding to develop with dynamism and a very high degree of technical competence. The conclusion can hardly be challenged that Russia is today leading the world in both its hydroelectric development program and in its many aspects of hydroelectric construction techniques, including specifically the use of hydromechanical fill techniques on earth dams and the extensive use of

precast concrete forms in construction of spillways, powerhouses, and other concrete structures. This is not true in the field of thermal-electric power, in which Soviet technology is substantially behind that in the United States.

2. Hydroelectric power now comprises approximately 20 percent of Soviet electric power generation in terms of both installed capacity and annual energy production. Within the 7-year plan ending in 1965 the installation of new hydroelectric capacity will comprise at least as high a proportion of total new installed capacity in the Soviet Union as hydro now provides in the existing Soviet power system. The new installed hydro capacity of the 7-year plan will very likely exceed the hydro installations of the preceding 7 years by at least 50 percent.

3. The Soviet engineers believe the present ratio of hydro to thermal capacities in their system is a desirable working proportion and intend to keep it at approximately this 20–80 ratio at least during the immediate future.

POWER DEVELOPMENT AND TRANSMISSION SYSTEMS IN THE U.S.S.R.

(By Harry A. Kuljian and Harvey F. McPhail)

INTRODUCTION

As an introduction to our report on the present and potential power and transmission developments in the U.S.S.R., it is believed that various comparative statistics with the United States will be of interest to the readers:

	U.S.A.	U.S.S.R.
Continental land area in square miles	3,082,000	8,600,000
Population in 1958	174,300,000	209,000,000
Persons per square mile	57	26
Potential hydropower in kilowatts	97,000,000	350,000,000
Installed electric power in kilowatts:		
Hydroelectric	30,098,000	10,500,000
Thermal electric	130,121,000	42,500,000
Total	160,219,000	53,000,000
Energy produced (million kilowatt-hours)	724,013	233,000
Energy produced per capita	4,159	1,115

It will be noted that the ratio of thermal to hydroelectric plants in both countries is almost identical; that is, about 4 kilowatts of thermal plants to 1 kilowatt of hydroplants.

The U.S.S.R. possesses vast water resources with a total annual discharge of 140 billion cubic feet. These are the largest water resources in the world, and make up about 10 percent of total world water power resources, compared to 3 percent for the U.S.A.

A very large percentage of the total water power potential in the U.S.S.R. is concentrated in the Asiatic parts of the country and a small percentage in the European part. In the Asiatic part of the U.S.S.R. about 55 percent of the water flows northward into the ice-bound arctic Ocean. This creates a real problem in the development of their river resources, because these rivers are of limited value insofar as economic exploitation of their entire length is concerned, since the largest flows of these rivers are in permanent frosted regions and unfavorable climatic conditions. The powerplants which are economical to construct would be located too far from the industrial centers. Consequently, they can develop large quantities of power far from the load centers, which necessitates transmission lines of higher voltage than are used in the U.S.A. Our highest transmission line voltage is 345 kv where in Russia 400-kv lines have been in operation since 1956 and they are now being changed to 500 kv. It is planned that in 1962, still higher voltages at 800 kv will be constructed

to take care of some of the very large hydroplants at present being constructed.

At present, only 10,500,000 kw capacity is installed in hydroelectric power, which represents less than 4 percent of potential Soviet hydroelectric development, which is approximately 350 million kw as compared with the U.S.A. potential of 97 million kw.

HYDROELECTRIC DEVELOPMENTS IN RUSSIA

The potential hydroelectric possibilities of the country are stated by the Russian engineers to be from 340 to 350 million kilowatts with an annual output of 1,700 billion kilowatt-hours per year. Many of the rivers are of such size as to permit developments at many sites of greater capacity than Grand Coulee, which is the largest hydroelectric development in the United States (2 million kw capacity).

The Kuybyshev plant of 2.3 million kilowatts capacity, which is in full operation, was visited by the party and two sites under construction, the Stalingrad plant with proposed capacity of 2,530,000 kilowatts and the Bratsk plant with proposed capacity of 4.5 million kilowatts, were also visited. One site on the Yenisey River is stated to have a potential capacity of 6 million kilowatts; one on the Ob River 6 million kilowatts and several others in excess of 2 million kilowatts.

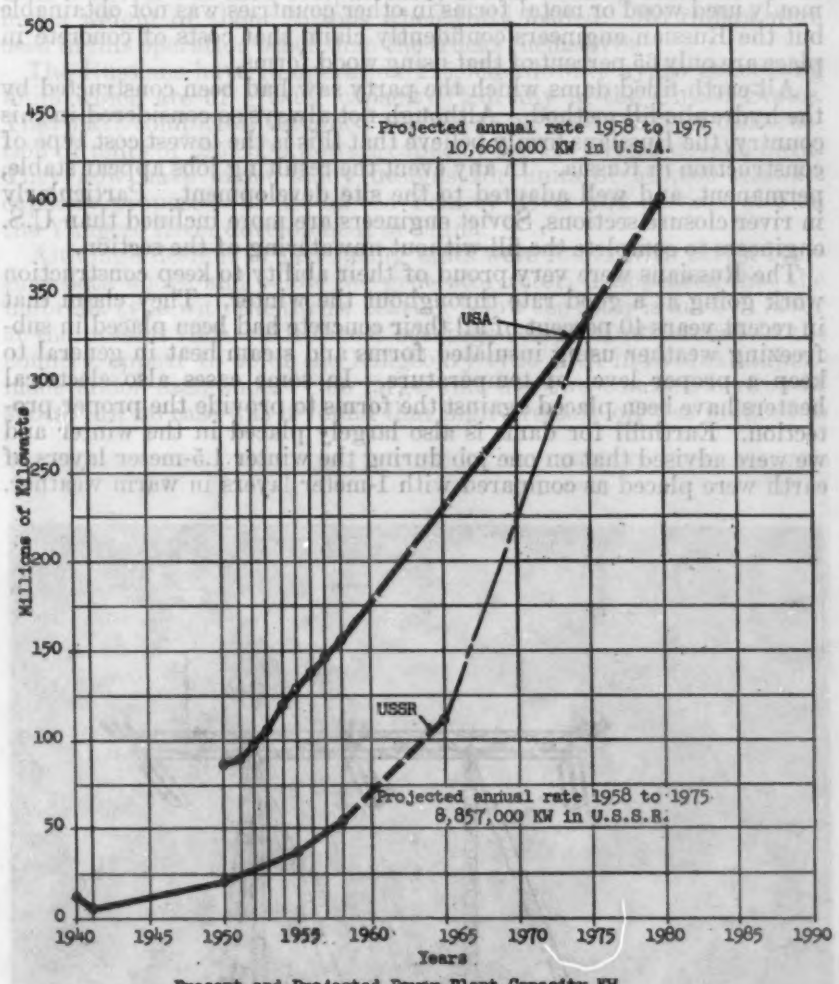
Preceding the revolution of 1917, the total installed capacity of all powerplants in Russia was about 1 million kilowatts with a total annual output of about 2 billion kilowatt-hours. At the present time there are about 120 major hydroelectric stations in operation, a total capacity of about 10.5 million kilowatts and in addition thermal capacity of about 42.5 million kilowatts. Total production in 1958 was reported to be 233 billion kilowatt-hours of which 20 percent was produced by hydroelectric plants. This is claimed to be the equivalent of 1,115 kilowatt-hours per capita.

In the current 7-year program it is planned that by 1965 the total installed capacity in the country will be 113 million kilowatts with an annual output of 520 billion kilowatt-hours. On the basis of the 1958 population this would be the equivalent of 2,450 kilowatt-hours per capita. The present ratio in the country is 20 percent hydro and 80 percent thermal. This ratio is expected to be maintained throughout the 7-year program ending in 1965.

The impressive thing regarding Russian power development is the speed of expansion both actual in recent years and predicted through 1965. The accompanying graph permits a visual picture of this rate of expansion. (See fig. 4 on opposite page.)

There has been considerable comment that the Russians are slowing up their hydro developments in favor of thermal developments which can be built faster and at less capital cost. This could not be verified by our observations. Certainly all hydro developments that were under construction were being pressed to completion as rapidly as possible. Many additional developments are in process of design and construction is apparently expected to start reasonably soon. It may be that more thermal plants than previously contemplated are under way or about to start but if this has resulted in any slowing up of the hydro program it is hard to detect. The Russians look upon their hydro possibilities as probably the most important asset of the country

FIGURE 4



Present and Projected Power Plant Capacity KW of U.S.A. and U.S.S.R.

and proudly state that even with the great plants already constructed only about 3 percent of the potential has been developed.

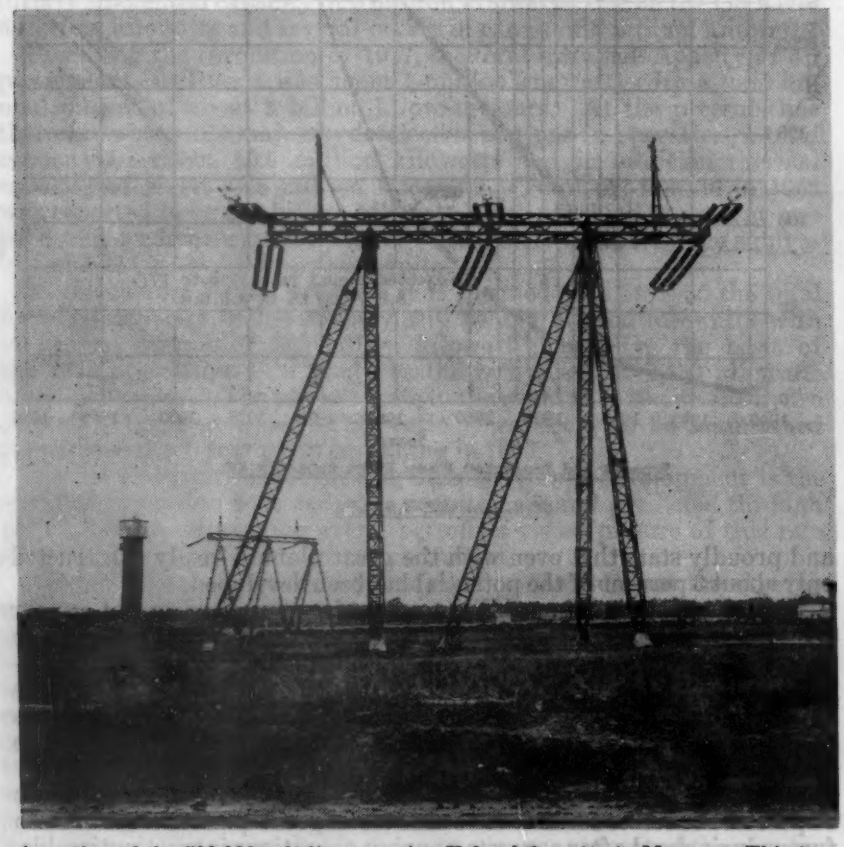
Regarding engineering ability and performance it does not appear that the Russian hydroelectric engineers are less qualified than those of any country in the world. Using as a base the engineering knowledge and experience accumulated by other countries, the Russians have advanced their own techniques during the past 20 years equally as fast in most details and perhaps faster than other countries in some few.

One striking item on large construction jobs is the widespread use of precast concerete forms. The absence of great quantities of wooden forms during and after concrete pouring operations is most noticeable.

Actual cost of this method of construction as compared to the commonly used wood or metal forms in other countries was not obtainable but the Russian engineers confidently claim that costs of concrete in place are only 65 percent of that using wood forms.

All earth-filled dams which the party saw had been constructed by the hydraulic fill method. Although not always so considered in this country, the Russians firmly believe that this is the lowest cost type of construction in Russia. In any event the resulting jobs appear stable, permanent, and well adapted to the site development. Particularly in river closure sections, Soviet engineers are more inclined than U.S. engineers to complete the fill without unwatering of the section.

The Russians were very proud of their ability to keep construction work going at a good rate throughout the winter. They claim that in recent years 40 percent of all their concrete had been placed in subfreezing weather using insulated forms and steam heat in general to keep a proper level of temperature. In some cases also electrical heaters have been placed against the forms to provide the proper protection. Earthfill for dams is also largely placed in the winter and we were advised that on one job during the winter 1.5-meter layers of earth were placed as compared with 1-meter layers in warm weather.



A section of the 500,000-volt line carrying Volga kilowatts to Moscow. This type of tower and transmission will be the backbone of the trans-Soviet grid.

This material was then compacted by trucks hauling material which had a weight of about 25 tons when fully loaded. No rollers were used in this operation other than the trucks themselves.

The Russians have in operation 115,000-kilowatt hydro generating units which are of greater capacity than any in the United States. They have completely designed and are about ready to start construction of units of 225,000-kilowatt capacity for the Bratsk development. They now have under study designs for units of 500,000-kilowatt capacity proposed for use on the Yenisey River and perhaps also on the Yangtze River development in China.

Although designs of generating units were found with thrust bearings both above and below the generator rotor, it appeared that the umbrella type with the thrust bearing below the rotor is most in favor at the present time. All thrust bearings being manufactured in the country appear to be of the Kingsbury type with individual adjustment under each shoe. One large unit has two concentric rows of shoes. In no case was it found that high-pressure oil was induced to

The U.S.S.R. has numerous hydro-testing dam laboratories such as this one and conducts hydroelectric research for half the world. At the Moscow testing laboratories of the Ministry of Power Station Construction, Senate observers found Russian models for Aswan Dam on the Nile in Egypt. Elsewhere, Russian tests were run for structures on the Yangtze River in China.

raise the rotor before starting of the unit. Whatever troubles they may have had initially with these large bearings they seem to have overcome. Bearings having a rated capacity up to 3,400 tons were seen.

Wherever head limitations permit, Kaplan type turbines are high in preference of Russian engineers. They are now carrying on rather extensive studies in connection with the development of what they designate as a Francis type runner with movable blades. This would amount to a Kaplan runner with the propeller blades moved further down on the hub and set at an angle perhaps approaching 45°. Russian engineers are of the opinion that such construction will permit the use of this type of runner well up into if not completely through the Francis turbine range of head. One phase of research on this runner is the use of two blades per blade hub.

Extensive model testing is carried on in laboratories in Moscow, Leningrad and Tbilisi covering all phases of hydraulic structures, hydraulic turbines, gates, and so forth. We noted the use of an electrical method for determining permeability through a dam foundation.

At the Stalingrad powerplant we were surprised to see mercury arc rectifiers being used to supply excitation to the generators. This plant, when completed, will be the largest in the world. At the Kuybyshev plan now in operation, where the units are of the same capacity as those at Stalingrad, 8 units are equipped with mercury arc rectifiers for excitation and 12 of the units have motor generator sets. The Soviet engineers state that based upon operating experience they prefer mercury arc rectifiers for excitation as being faster and more reliable and providing better transmission line stability. Certainly from the comparative bulk of machinery and materials required for each type of excitation it would seem that the mercury arc type should cost only a fraction of that of direct connected exciters for very large low-speed generating units.

In one respect certainly, Soviet construction does not measure up to that of the United States. That is in the general finish and details of building construction. Conduits, wires, cables, piping, lighting fixtures, and so forth, are not installed with the uniformity, neatness and generally permanent appearance that prevails in the United States. Stairways particularly indicate the lack of attention to these details. It is not uncommon to find risers of several heights in one flight of stairs and the construction seems to be such that the front edges of the steps chip and break quite easily. Most all stairways in powerplants that had been operating any length of time seemed to show rapid deterioration.

The Russian engineers take great pride in the speed at which their construction is accomplished. Customarily, work is carried on in a three-shift basis and is accomplished with great expedition. In hydroplants they customarily follow construction with installation of generating equipment much more closely than is ordinarily done in the United States. For example, in the Kuybyshev plant the first 115,000-kilowatt generating unit was placed in operation at the end of 1955, 11 units were added during 1956, and the last 8 units were all in operation by September 1957. This is probably a world's record.

During the trip 12 powersites were visited. Four of these were in construction stage and eight were in operation. Visits to such a few

plants cannot be said to give an accurate picture of all hydroelectric plants constructed and proposed for construction in the Soviet Union. However, due to the variation in size, hydraulic capacity, and head, we feel that a very clear concept of Russia's abilities and performance in this field was gained.

Due to the absence of a recognized rate of exchange, it is extremely difficult to determine just what the costs of construction in Russia are. The Russian official rate of exchange is 4 rubles per dollar; for tourists they have a special rate of 10 rubles per dollar, and it is understood that in money markets in other countries exchange as high as 20 to 25 rubles per dollar can be secured. For this reason it is felt that any cost data secured in Russia is not of great significance. They advised that the cost of thermal developments is the equivalent of from $120 to $130 per kilowatt of capacity and that the resulting cost per kilowatt-hour of output is in the neighborhood of 10 mills. On the other hand, some of the large hydro developments are stated to have actual or anticipated cost of from one-half to 1 mill per kilowatt-hour. Even in a relatively small plant of 110,000 kilowatts' capacity, cost is only expected to be 2½ mills per kilowatt-hour. All these figures are on the basis of the exchange rate of 10 rubles per dollar.

Under the Soviet type of government it does not appear to be too great a problem to arrange for disposal of energy generated, even where the hydroelectric site is remote from areas of reasonably heavy population. It appears to be customary to simply move in an industry to the vicinity of the site, together with the necessary people for the operation of such an industry. On large hydro developments is appears to be customary to build construction camps in a rather permanent fashion. In particular, apartment dwellings built at the site are nearly always proposed to be used as a permanent residence for workers in the industries which will be settled at the site.

In conclusion, as a general comment, it appears that the Russian engineers and constructors compare well with those of the United States and other countries. Their engineering appears to be sound and they devote a great deal of attention to studies of design methods and procedures which will permit their developments to be more economical, capable of faster construction, and better operating units when completed. Literally hundreds of new starts have been made in the country in the past 4 or 5 years and many more are being readied to start as fast as design work can be completed. The Russians are determined to make the best use of their resources, and the planning work observed clearly indicates that every possible step is being taken to assure that the maximum in the way of power generation is secured from each river system. The Russians consider it more important to develop every last kilowatt that a river will produce than to try to achieve a point where the greatest number of kilowatts for a given expenditure will be secured. Great attention is being paid to the installation of peaking capacity for coordination with thermal capacity. It is evident that during the foreseeable future thermal capacity will continue to predominate and great value will be attached to hydro peaking capacity.

THERMAL POWER DEVELOPMENTS IN RUSSIA

Examination of thermal development was not a primary objective of the delegation; nevertheless, some information was gathered in this connection.

It appears that 100,000- to 150,000-kw turbo generator units are now considered as fairly standard for several present and proposed installations. Several plants are in construction or under consideration with total capacities of about 600,000 kw. Considerable effort is being devoted to standardize new plants on the basis of unit type layouts.

Manufacturing facilities which were visited in Leningrad indicated that steam boilers and steam turbines of 1,800 and 2,400 pounds per square inch pressure and from 1,000° to 1,050° F. superheat can be manufactured in units of 100,000- to 150,000-kw capacity. Such units are very similar to those in the U.S.A. and appear to be very well designed and capable of good performances. Most of the larger units are designed to operate with reheat cycles.

During a visit to the exposition grounds in Moscow, many models were observed of units large enough to produce 400,000 to 500,000 kw. There is no indication, however, that up to the present time units larger than 150,000 kw have been employed. Due to the Russian desire to expedite time of construction as well as reduce the amount of capital investment per kilowatt of installed capacity, more than normal attention is being concentrated on considerations of large thermal plants.

It is understood that Russian engineers and metallurgists have developed steel alloys to give satisfactory performance under high pressure and temperature conditions. We were advised that they are manufacturing all sizes of seamless steel tubes from 2 to 12 inches in diameter.

The only steamplant visited was a small and rather old plant in Leningrad. This plant was originally built in 1897, rebuilt in 1915. New equipment consisting of four units of 35,000 kw each was installed in 1930, and was then ruined during the war. It was rebuilt in 1947. The present capacity is 94,000 kw, consisting of one 15,000, one 24,000,

one 25,000, and one 30,000 kw units. The plant generates electricity and also furnishes steam at two different pressures in heating of apartments and office buildings and for hot water supply. After deducting the amount of heat used for heating and hot water the B.t.u. per kilowatt hour for electric generation is fairly low, somewhere around 6,500 to 7,000 B.t.u.'s per kilowatt-hour.

The station was not impressive and would be considered out of date in this country. It has the appearance of some of our old industrial powerplants.

Pulverized coal was used for fuel. We were surprised by the long horizontal distances between the pulverizers and the boiler, which is not in keeping with our practice of designing for the shortest distance between these points so as not to permit accumulation of pulverized coal in the transport lines.

We understand that the Soviet Union has an enormous reserve of lignite and peat. We were advised that they have developed very good techniques for drying and using this fuel with very large moisture and ash contents.

RUSSIAN TRANSMISSION SYSTEMS

The construction of transmission lines in the U.S.S.R. has kept pace with the development of generating capacity. It has been particularly stimulated by hydroelectric developments due to their general remoteness from points of large usage. The overall pattern of development has been similar to that in other countries. Ordinarily, voltages of about the 35-kv class were employed at the outset for light loads and short distances and this class remains as the preponderant subtransmission level. The next logical step for longer distances and larger loads was the 110- to 154-kv class, which has become and probably will remain for many years, the greatest in total mileage. There followed next the 220- to 230-kv class and in recent years the 400- to 500-kv lines.

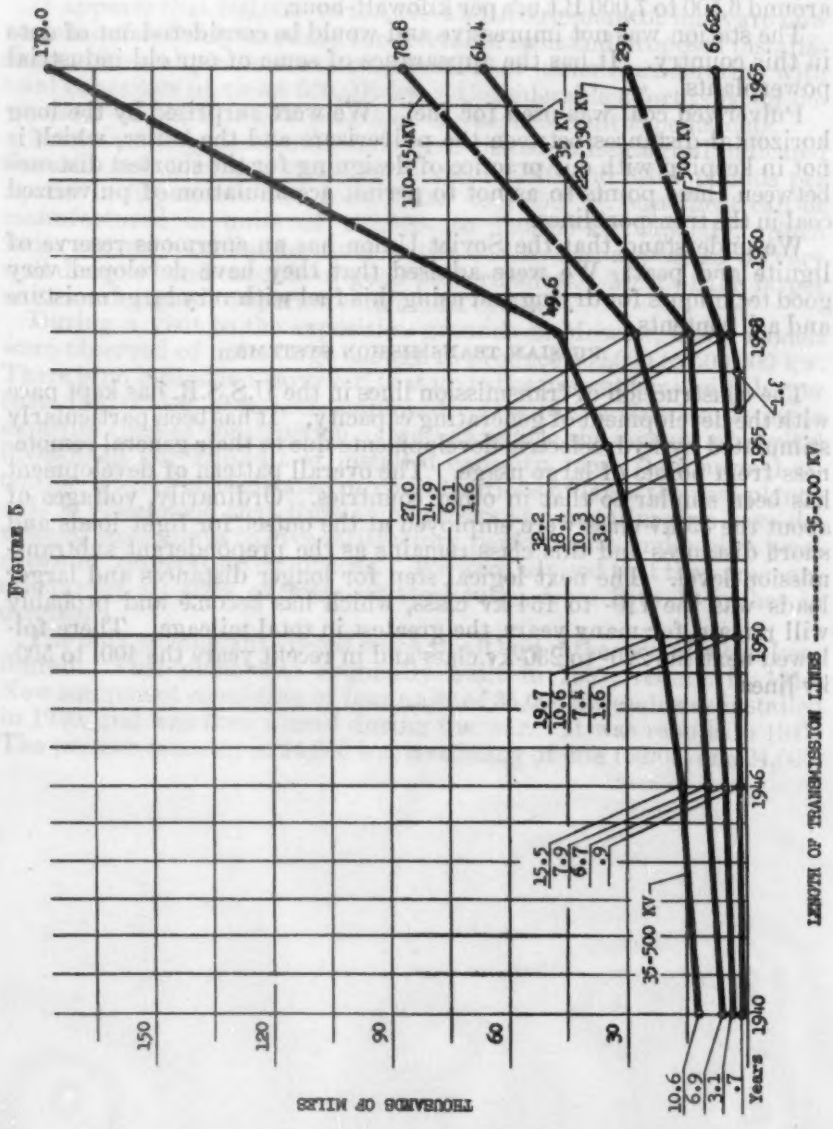

179.0
78.8
64.4
29.4
6.625
110-154 KV
35 KV
220-330 KV
500 KV
49.6
1.f
27.0
14.9
6.1
1.6
32.2
18.4
10.3
3.6
19.7
10.6
7.4
1.6
15.5
7.9
6.7
.9
35-500 KV
10.6
6.9
3.1
.7
1940
1946
1950
1955
1958
1960
1965
Years
150
120
90
60
30
THOUSANDS OF MILES
LENGTH OF TRANSMISSION LINES ----------35-500 KV

FIGURE 5

The claimed mileages for different voltage classes for the period since 1940 are shown on the attached graph. The total mileage for 1940–58 and the predicted for 1965 are given in the following tabulation (see fig. 5 on opposite page):

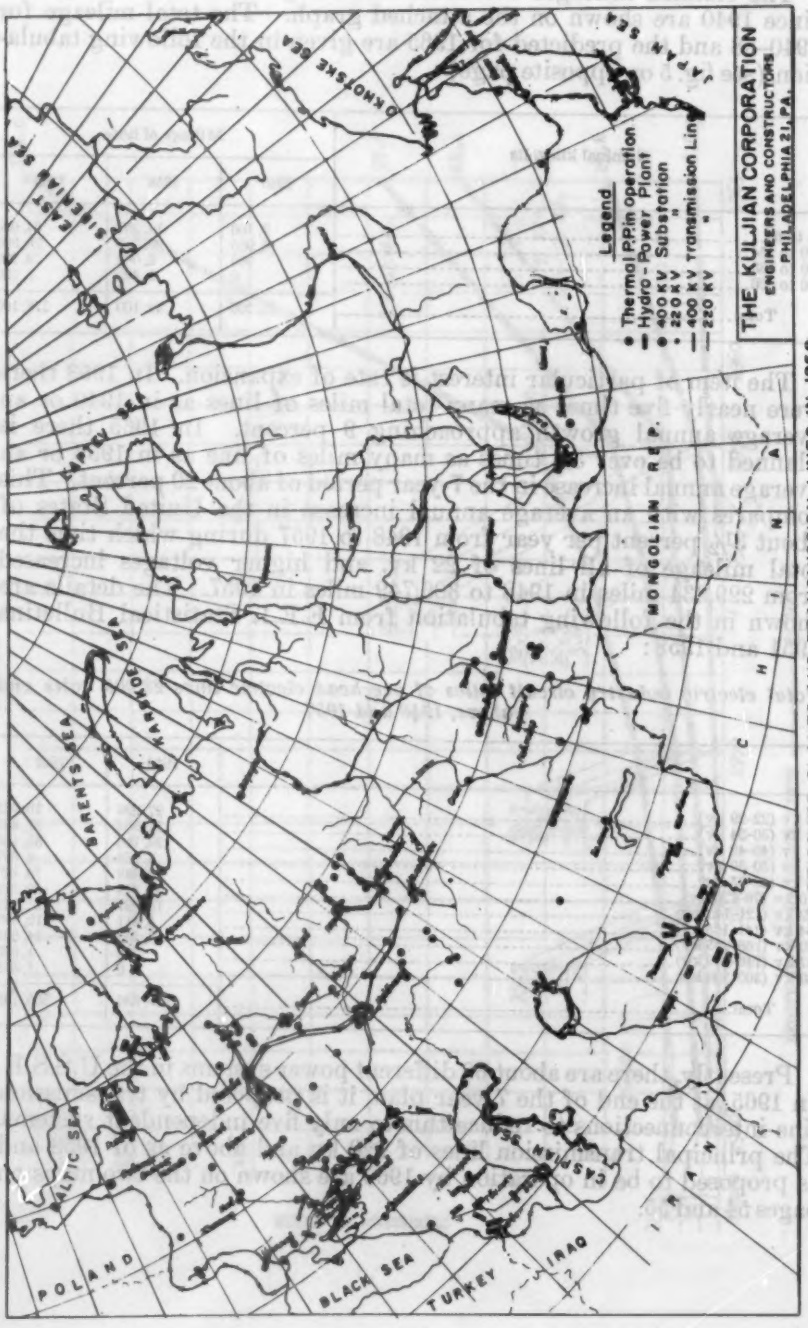
Nominal kilovolts	Mileage of lines		
	1940	1958	1965
33 to 66	3,100	14,800	64,000
110 to 154	6,900	26,700	78,300
220 to 330	700	6,000	29,200
400 to 500	0	1,600	6,600
Total	10,700	49,100	178,100

The item of particular interest is rate of expansion. In 1958 there were nearly five times as many total miles of lines as in 1940 or an average annual growth approaching 9 percent. In 1965 there is planned to be over 3.6 times as many miles of line as in 1958 or an average annual increase in the 7-year period of about 20 percent. This compares with an average annual increase in the United States of about 3½ percent per year from 1948 to 1957 during which time the total mileage of all lines of 22 kv. and higher voltages increased from 229,334 miles in 1948 to 306,749 miles in 1957. The details are shown in the following tabulation from E.E.I. Statistical Bulletins 1951 and 1958:

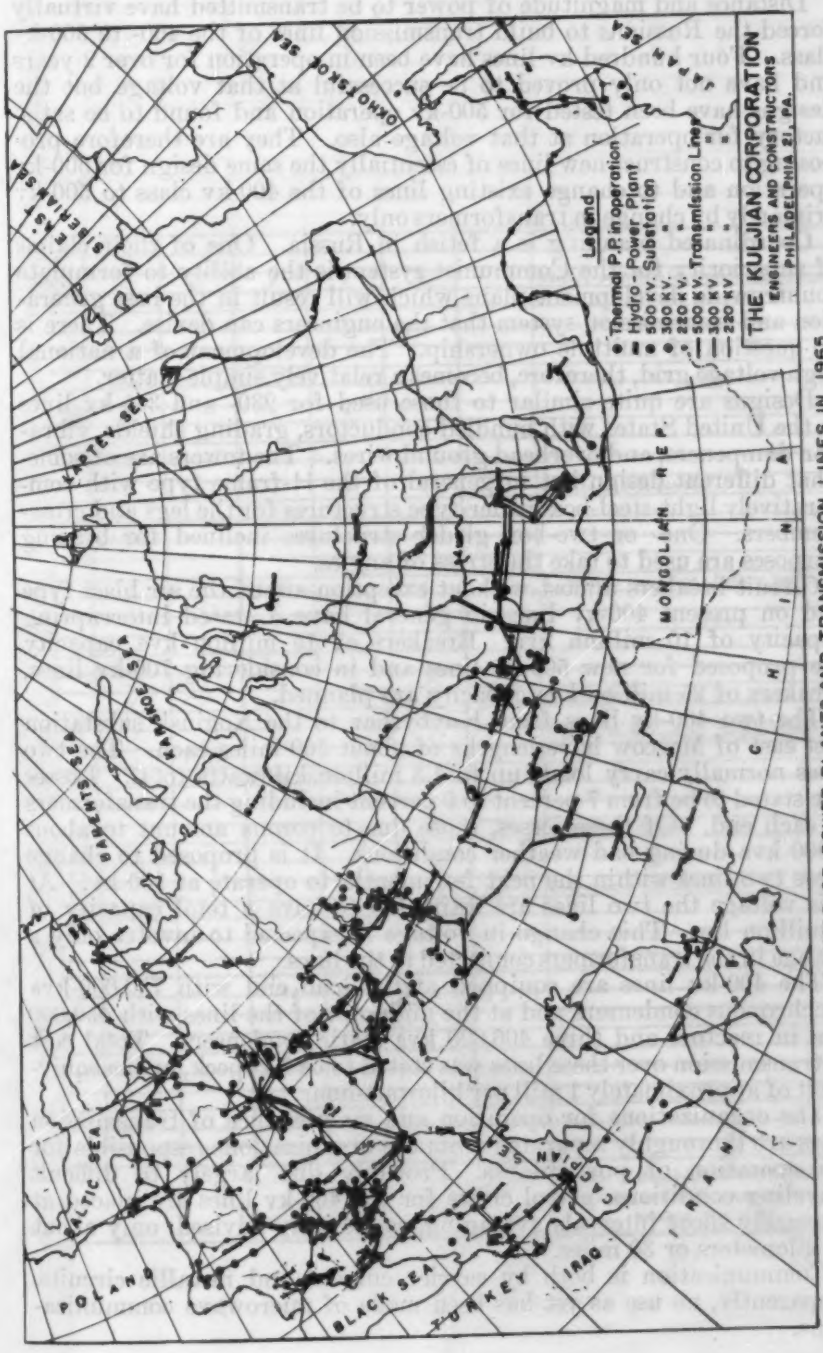
Total electric industry circuit miles of overhead electric lines 22,000 volts and above, 1948 and 1957

	1948	1957
22 kv (22–29 kv)	27,029	19,967
33 kv (30–34 kv)	52,963	57,833
44 kv (40–49 kv)	29,106	33,164
55 kv (50–59 kv)	4,168	4,607
66 kv (60–75 kv)	50,449	70,146
110 kv (76–120 kv)	37,574	59,512
132 kv (121–140 kv)	15,637	31,545
154 kv (141–165 kv)	5,411	12,487
220 kv (166–245 kv)	6,206	14,851
287 kv (246–299 kv)	791	1,023
330 kv (300–360 kv)	0	1,614
Total	229,334	306,749

Presently, there are about 60 different power systems in the U.S.S.R. In 1965, at the end of the 7-year plan, it is proposed by transmission line interconnections to reduce this to only five independent systems. The principal transmission lines of 220 kv and above as of 1958 and as proposed to be in operation by 1965 are shown on the two maps on pages 54 and 55.



MAP OF POWER PLANTS AND TRANSMISSION LINES IN 1958



MAP OF POWER PLANTS AND TRANSMISSION LINES IN 1965

49824—60——5

MAP OF POWER PLANTS AND TRANSMISSION LINES IN 1958

Distance and magnitude of power to be transmitted have virtually forced the Russians to build transmission lines of the 400- to 500-kv class. Four hundred kv lines have been in operation for over 2 years and have not only proved to be successful at that voltage but the designs have been tested for 500-kv operation and found to be satisfactory for operation at that voltage also. They are therefore proposing to construct new lines of essentially the same design for 500-kv operation and to change existing lines of the 400-kv class to 500-kv primarily by change in transformers only.

Coordinated planning is a fetish in Russia. One of their claims of superiority for the Communist system is the ability to formulate countrywide development plans which will result in the best generation and transmission system that the engineers can devise. There is no question of multiple ownership. The development of a national high voltage grid, therefore, becomes a relatively simple matter.

Designs are quite similar to those used for 230- and 345-kv lines in the United States with bundled conductors, grading shields, vibration dampeners, and overhead ground wires. The towers are of somewhat different design but in general of the H-frame type with comparatively light-steel-box girder-type structures for the legs and crossmembers. One- or two-box girder structures inclined for bracing purposes are used to take the stress of angles.

Circuit breakers almost without exception are of the air blast type and on present 400-kv lines in general have a stated interrupting capacity of 10 million kva. Breakers of 15 million kva capacity are proposed for new 500-kv lines and in considering 700-kv lines, breakers of 25 million kva capacity are planned.

The two 400-kv lines from Kuybyshev to the Noginsk substation just east of Moscow have lengths of about 560 miles each. The two lines normally carry loads up to 1.3 million kilowatts total. Losses are stated to be from 7 percent to 9 percent including the transformers at each end. Of these losses, those due to corona amount to about 7,000 kva during bad weather conditions. It is proposed to change these two lines within the next few months to operate at 500 kv. At this voltage the two lines are estimated to have a total capacity of 2 million kw. This change in voltage is expected to involve only a change in the transformers connected to the lines.

The 400-kv lines are equipped at the load end with 750,000-kva synchronous condensers and at the midpoint of the lines with 450,000 kva in reactors and three 406,000 kva static condensers. Total cost of transmission over these lines was stated to be 1 kopeck, or the equivalent of approximately 1 mill per kilowatt-hour.

The organizations for operation and maintenance of transmission lines are thoroughly separated from the organizations responsible for the operation of powerplants. Probably due largely to difficult traveling conditions, patrol crews for the 400-kv lines are placed at extremely short intervals averaging, so we were advised, only about 50 kilometers or 30 miles.

Communication is both by carrier current and metallic circuits. Apparently, no use as yet has been made of microwave communications.

TABULATED INFORMATION

ITEM NO		PLANT NAME AND LOCATION	CAPACITY MW PRES.	CAPACITY MW ULT	KWH/YR X10⁹	NUMBER AND CAP MW	R.P.M	TURBINE TYPE	GEN. VOLT KV
1	V	Zages on Kura River 15 Km fr Tbilisi	36 8	36 8		4- 3.2 2-12.0	2140 1570	Francis Kaplan	6.4
2		Nardevan on Khrami River		140.0	28	2-70.0		Pelton	
3	V	Station No. 1 " " "	112.8	112.8	.34	3-37.6		Pelton	10.5
4	V	Station No. 2 " " "	1100	110.0	.35	2-55.0		Pelton	10.5
5		Station No. 3-4-5 " " "		3600	1.26				10.5
6	V	Krasna Polyana on Mzymta River	28.0	28.0	15	4- 7.0	5000	Francis	6.3
7		Future 4 more Station on Mzymta River		112.0					
8	V	Tsimlyanskaya on Don River	164.2	164.2	6 to 1.0	4-40.0 1- 4.2	88.2	Kaplan	10.5
9		Ivankovo on Volga River	30.0	30.0					
10		Uglich " " "	220.0	220.0		4-55.0			
11		Rybinsk " " "	330.0	330.0		6-55.0			
12		Gorkov " " "	400.0	400.0	1.5	8-50.0	685		13.8
13		Cheboksary " " "		1 400.0					
14	V	Kuybyshev " " "	2 300.0	2 300.0	11.0	20-115.0	682	Kaplan	13.8
15		Saratov " " "		1 000.0					
16	V	Stalingrad " " "	345.0	2 530.0		22-115.0	682	Kaplan	13.8
17		Astrakhan' on Caspian Sea		500.0					
18		Verkhne, Kama on Kama River		400.0					
19		Kama " " "		600.0		24- 25.0			
20		Votkin " " "		1 000.0					
21		Nizhne-Kama " " "		1 000.0					
22	V	Irkutsk on Angara River	660.0	660.0	4.1	8- 82.5	83.3	Kaplan	13.8
23		Sukhovo " " "		8 840.0					
24		Telma " " "							
25	V	Bratsk " " "		4 500.0	21.7	20-225.0	125.0	Francis	15.3
26		Ust'-Ilim " " "							
27		Boguchany " " "							
28		Sayan' on Yenisey River		4 000.0					
29		" " "		3 000.0					
30		" " "							
31		Krasnoyarsk " " "		5 000.0	19.3	14-300.0	93.0		15.75
32		Yenisey " " "		6 000.0					
33		Osinovo " " "		2 000.0					
34		Bukhtarma on Irtysh River		500.0	2.5	7-72.0		Kaplan	13.8
35		Ust-Kamenogorsk " " "		450.0		6-75.0			13.8
36		Shul'ba " " "		1 000.0					
37		13 more Stations " " "		2 550.0					
38		Kamen' on Ob River			2.6				
39		Novo-Sibirsk " " "	400.0	400.0	1.7	7-57.0		Kaplan	13.8
40		Nizhne-Ob' " " "							
41		7 more Stations " " "							
42		Kakhovka on Dnieper River	312.0	312.0	1.4	6-52.0		Kaplan	
43		Dnepro GSK " " "	650.0	1 400.0	3.1	9-72.0		"	
44		Dneprodzershinsk " " "		350.0	1.25	8-43.0		"	
45	V	Kremenchug " " "		624.0	1.5	12-52.0		"	
46		Kanev " " "							
47		Kiev " " "		614.0	3.15				
48		8 more Stations " " "							
49		Sevan on Razdan River	32.0	32.0		2-16.0		Francis	10.0
50		Atarbekyan " " "	84.0	84.0		2-42.0		"	10.0
51	V	Gyumush " " "	224.0	224.0		4-56.0		"	10.0
52		Arzn " " "	63.0	63.0		3-21.0	300.0	"	10.0
53		Kanaker " " "	110.0	110.0		4-15/2-25		"	10.0
54	V	Yeravan " " "	45.0	45.0		2-22.5		"	10.0
55		3 more Stations " " "		82.0					
56		Murmansk on Yuloma River	48.0	48.0		4-12.0			
57		Svir Station No. 1 on Svir River	Inundated by Construction of No 2						
58		" " No. 2 " " "	160.0	160.0		4-40.0			
59		" " No. 3 " " "	120.0	120.0		4-30.0			
60		Volkhov on Volkhov River	64.0	64.0		8- 8.0			
61		Niva Station No. 1-2-3 on Niva River		250.0					

V—Plant Visited

49324 O - 60 (Face p. 56) No. 1

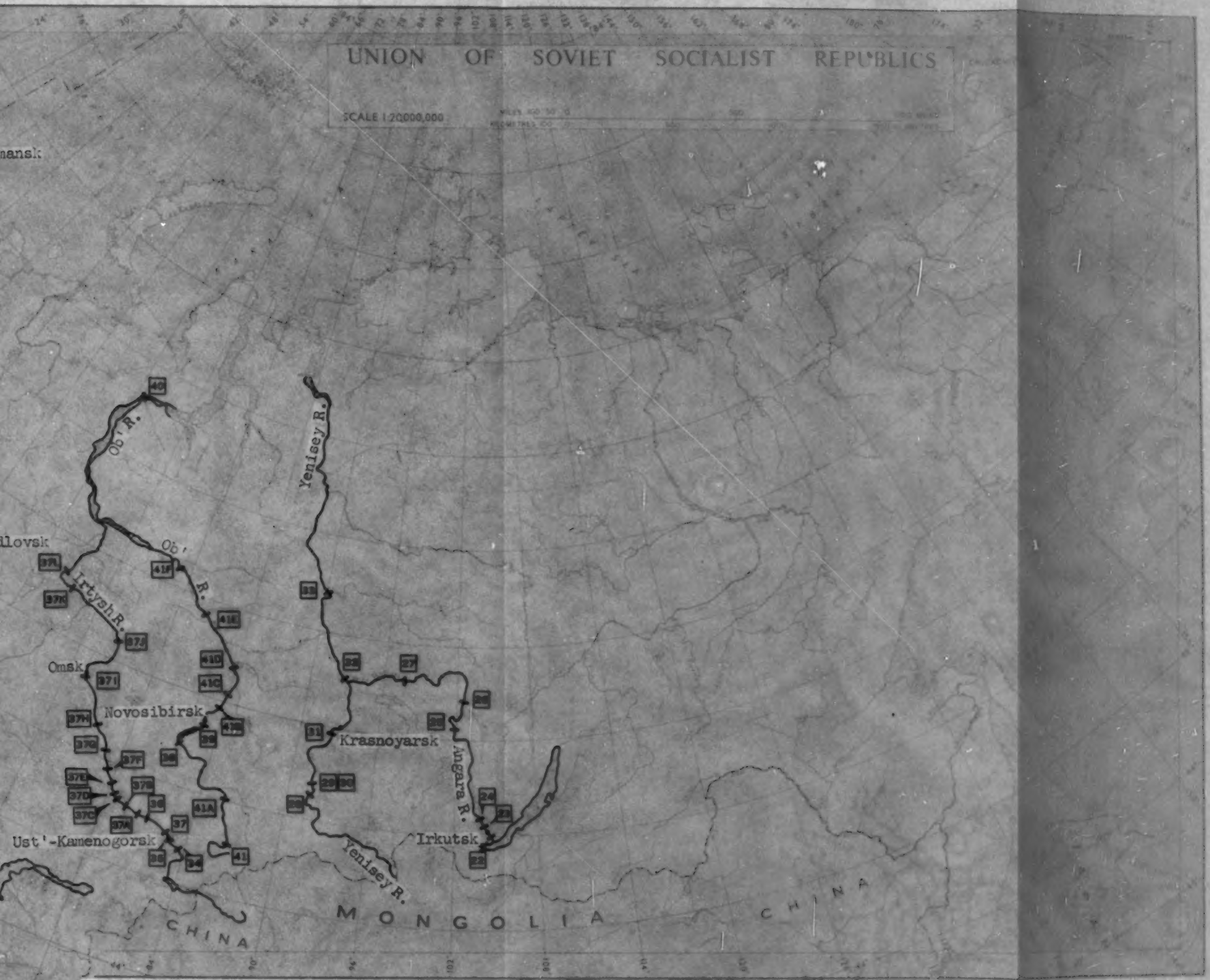
ON ON SOME OF THE HYDRO-ELECTRIC PROJECTS

RBINE YPE	GEN. VOLT KV.	TRANSM. VOLT. KV.	YEAR STARTED	YEAR 1ST OPER	YEAR COMP	DAM TYPE	DAM DIM	HEAD IN METERS	RES'VOIR CAP. * X 10^9 M^3	RIVER FLOW ANN. M^3	RIVER FLOW MAX M^3/sec	RIVER FLOW MIN M^3/sec	WATER USE ELEC. GEN.	WATER USE NAV.	WATER USE IRRIG.	WATER USE FLD. CON	WATER USE FISHERY	COST	REMARKS
ncis	6.4	35/110/220		1927		Concrete		230					✓	x	x	x			
plan																			
lton					Future			5000	* 0.30				✓	x	x	x			
lton	10.5	220	1947		1949	Rock Fill		4200	* 0.30				✓	x	x	x			
lton	10.5	220	1954		1961	Rock Fill		3300					✓						
	10.5	220			Future			51/186/9					✓	x	x	x			
ancis	6.3	110	1946		1950	Earth Fill		1100	1day Supply										
plan	10.5	110/220	1949		1952	Earth Fill + Conc Spill way		235	23.5				✓	This Plant has Fish Elev.			✓		
					1937			110											
		110/220			1940			110											
		110/220			1941			180											
	13.8	110/220		1955	1956			160	8.7										
								180											
plan	13.8	110/220/330	1950	1955	1957	Earth Fill + Conc Spill way		24/19	58.0	240×10^9	72 000	1 000	✓	✓	Future	x	✓		Mercury-Arch Rect for field current
								140											
plan	13.8	220/500	1948	1959	1961	Earth Fill + Conc Spill way		26/24/20/17			61 000		✓	✓	Future	x			
								4 or 5											
					Design Stage			220											
					Operating			190											
					Const Stage			170											
					Design "			190											
plan	13.8	110/220/330	1950	1956	1958	Earth Fill		32/26/25	*46.0	63×10^9	2 000								
								130											
								120											
ancis	15.3	220/500	1956	1961	1963	Earth Fill + Conc Spill + PP		1020	*50.0	9.1×10^9	8 300	2 900	✓	✓	x	x	x		Mercury-Arch Rect for Main Gen. Excitation
								930											
								690											
	15.75	110/220/500						1010	30.0	79×10^9	30 000	300-500	✓	✓	x	x	x		
plan	13.8	110/220	1953		Operating	All Conc		650	*31.0				✓	✓	x	✓	x		3 Locks for Navigation
	13.8				"	" "		400	* 0.6				✓	✓	x	✓	x		
		220/330	Design Stage					520	* 3.8				✓	✓	x	✓	x		
								1880											
			Design Stage			Earth + Conc no reg. Spill			*540				✓	✓	6.5×10^6 hec	✓	x		2 Locks for Navigation - Outdoor Station
plan	13.8	110/220		1957	1959	" " " Spill + no reg. Sp		140	* 9.0				✓	✓	x	✓	x		3 " " "
		500 or 1200	Design Stage			" " " " " " "			*2550				✓	✓	x	✓	x		1 " " " Future
Kaplan				1955	1956	Earth + Conc Spill way		164		53×10^9			✓	✓	✓	✓	x		
"		110/220	1928	1932		All Concrete + Spill way		385	15				✓	✓	x	✓	x		3 Locks for Navigation
"			Under Const			Earth + Concrete " "		124											
"		154/330	" "			" " " " "		168	* 9.0		12 000	300	✓	✓	x	✓	x		1 Lock for Navigation - Outdoor Station
														Future					
			Project Stage											Future	3.5×10^6 hec				
rancis	10.0	10/110			1949	none		650				65	✓	x	✓	✓	x		Underground Station
"	10.0	10/110			1959			1350				65	✓	x	✓	✓	x		
"	10.0	10/110			1953			3000	.0003			65	✓	x	✓	✓	x		
"	10.0	10/110			1956	All Conc + Spill way		1150				65	✓	x	✓	✓	x		Underground Station
"	10.0				1937			1740				65	✓	x	✓	✓	x		
"	10.0	10/110			1960			850				65	✓	x	✓	✓	x		
								1260											
					1952			140					✓						
					1932			105					✓						
					1926														
								1300											

*Useful Capacity

THE KULJIAN CORPORATION
ENGINEERS AND CONSTRUCTORS
PHILADELPHIA 21, PA

49824 O-60 (Face p. 56) No. 2


UNION OF SOVIET SOCIALIST REPUBLICS
SCALE 1:20,000,000
mansk
Ob' R.
Yenisey R.
Ob'
R.
Irtysh R.
Omsk
Novosibirsk
Krasnoyarsk
Angara R.
Irkutsk
Ust'-Kamenogorsk
Yenisey R.
MONGOLIA
CHINA
CHINA

We were advised that Russian engineers are giving consideration to the use of alternating current transmission of 700 kv and even 1,000 kv. Also, without being supplied with any details regarding methods to be employed, we were informed that they are considering direct current transmission at 800 kv. At this voltage they expect that their losses will amount to only 4 percent for lines about 600 miles long as compared to the 7½ percent now being experienced on the 400 kv. a.c. lines from Kuybyshev to Moscow.

It was not indicated that the Soviets have developed any startling new designs or methods for transmission line usage as compared to those in use in the United States. Neither does it appear that they are behind in any way by the same comparison. They are successfully operating at voltage levels well above that being used in the United States and confidently expect to go on to still higher levels.

ANGARA RIVER SYSTEM

The source of the river, Angara, is Lake Baikal. The Angara flows over 1,800 km and empties into the Yenisey River. The total head of the river is 378 meters. The enormous regulating capacity of Lake Baikal makes the flow of Angara exceptionally uniform.

The construction of powerplants also solves the problem of navigation through the existing rapids.

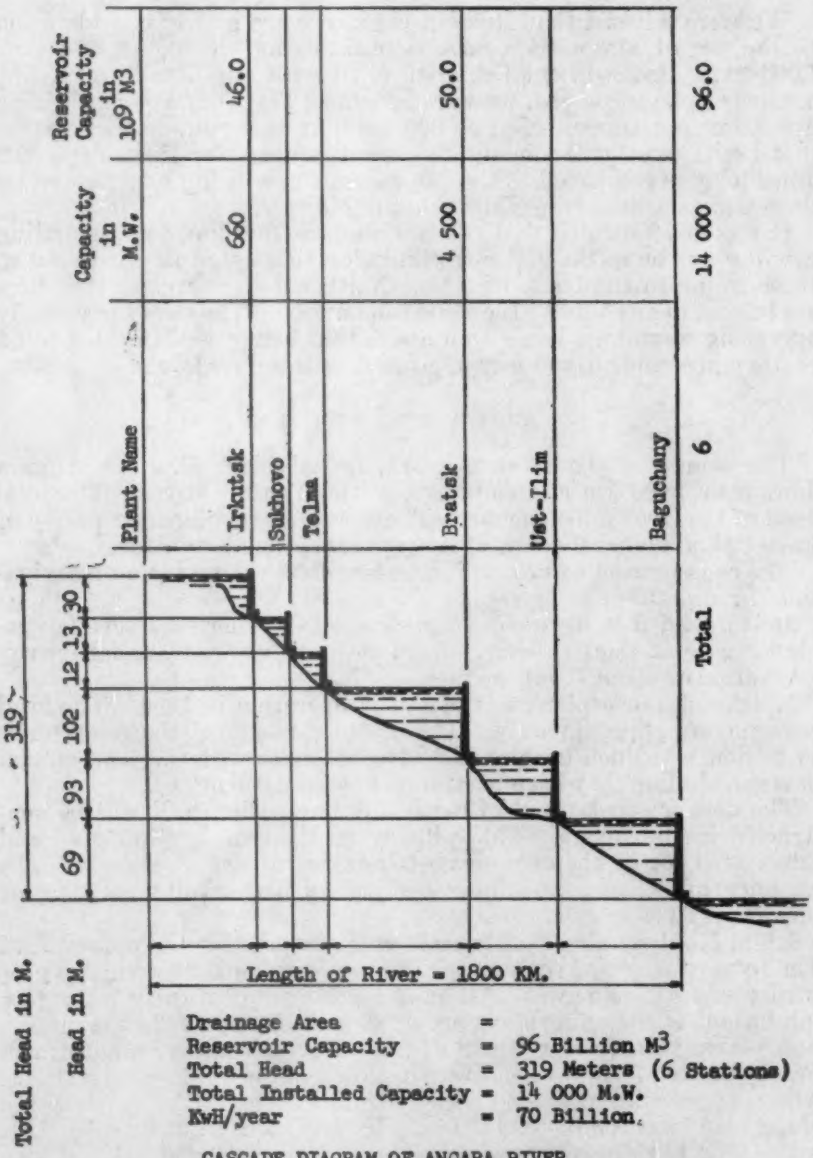
It is intended to have on this river the following six hydro powerplants with a total capacity of 14 million kw and annual energy generation of about 70 billion kwh.

1. Irkutsk powerplant was placed in operation in 1956. The head is 28 meters approximately. The useful capacity of the reservoir is 46 billion m^3 which enables almost constant riverflow. The annual flow is 63 billion m^3 with a maximum flow of 2,000 m^3/sec.

The dam is constructed of earth. A navigation lock will be constructed in the future. The spillway on the dam is eliminated and substituted for by the openings between the turbine discharges. The capacity of 16 such openings together with the full load flow of turbines is 6,000 m^3/sec.

Eight Kaplan units of 82.5 mw each are installed in the powerhouse. The total capacity of the plant is 660 mw with an annual energy generation of 4.1 billion kwh. All units operate automatically. Outdoor substations at the powerplant provide for 110 kv and 220 kv transmission. Two transformer banks of 210 mva each and two autotransformer banks of 414 mva each are installed in the outdoor substations. All sluice gates are provided with hydraulic drives. The construction of the plant was completed in 1958. In the future a 500 kv substation will be provided for connection with other power systems. A highway is being constructed along the top of the dam with provisions for future railroad tracks.

2. Sukhovo and Telma powerplants will be the next plants along the flow of the river with total capacity of 500 mw. These plants may be constructed in the future. The head of the Sukhovo plant will be 13 meters and Telma will be 12 meters.



CASCADE DIAGRAM OF ANGARA RIVER

3. Bratsk plant now under construction will be the first powerplant in the world with a total capacity of 4,500 mw installed under the same roof and with hydroelectric units as large as 225 mw each. The concrete dam with spillway is 840 meters long and has a maximum height of 126 meters. The navigation locks will be constructed in the second stage. On the top of the dam will be located two sets of railroad tracks and a highway. Annual flow is 91 billion m³, with a maximum

flow of 8,300 m^3/sec. and minimum flow of 2,900 m^3/sec. The head will be 94 meters and the reservoir capacity 175 billion m^3 with useful capacity of 50 billion m^3. Twenty radial flow units of 225 mw (125 rpm) each will be installed in the powerhouse. The annual energy generation will be 21.7 billion kwh. Outdoor substations at the plant will be of 220 kv and 500 kv. Construction started in 1956 and completion is planned in 1963.

4. Ust'-Ilim powerplant now in design stage, will be approximately of the same construction as the Bratsk powerplant except that the reservoir capacity will be much less and the total capacity will be about 3,000 mw with an annual energy generation of 20.66 billion kwh.

5. Boguchany powerplant will be constructed in the future. Its capacity is planned to be of 2,700 mw with an annual energy generation of 18 to 19 billion kwh.

YENISEY RIVER SYSTEM

The Yenisey River is the largest river in U.S.S.R. Its length is 4,100 km with a total head of 1,600 meters. The drainage area of Yenisey is 2,700,000 km^2. The average flow at the mouth of the river is 17,000 m^3/sec.

On the Yenisey River the construction of a cascade of powerplants with total capacity of 19,200 mw with annual energy generation up to 120 billion kwh is possible. The construction of hydro powerplants will also greatly improve the navigational conditions.

The projected plants are as follows:

1. Sayana plant to be constructed in the future with a total capacity of 4,000 mw.

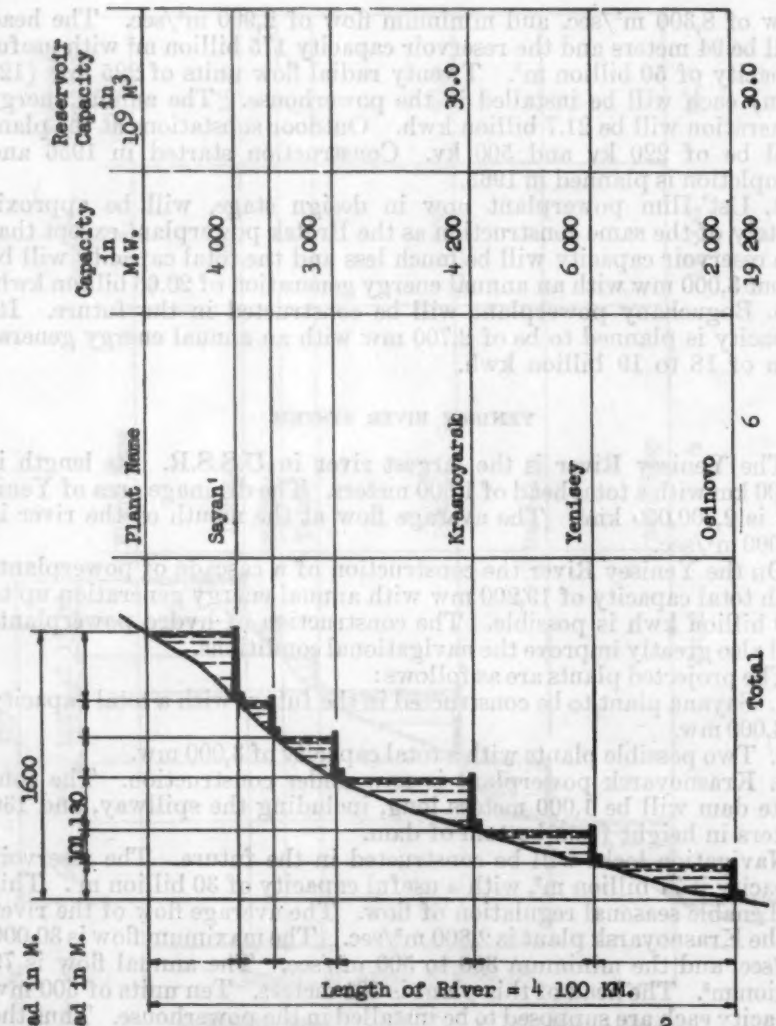
2. Two possible plants with a total capacity of 3,000 mw.

3. Krasnoyarsk powerplant is now under construction. The concrete dam will be 1,000 meters long, including the spillway, and 130 meters in height from bottom of dam.

Navigation locks will be constructed in the future. The reservoir capacity is 77 billion m^3, with a useful capacity of 30 billion m^3. This will enable seasonal regulation of flow. The average flow of the river at the Krasnoyarsk plant is 2,800 m^3/sec. The maximum flow is 30,000 m^3/sec. and the minimum 300 to 500 m^3/sec. The annual flow is 79 billion m^3. The head of this plant is 101 meters. Ten units of 500 mw capacity each are supposed to be installed in the powerhouse. Thus the total capacity of the plant will be 5,000 mw. The outdoor substations will be 110 kv, 220 kv, and 500 kv.

4. Yenisey powerplant is the largest possible hydro powerplant on the River Yenisey. After the construction of Bratsk plant on Angara and of the Krasnoyarsk plant on the Yenisey River, the regulated flow of both rivers at the Yenisey plant will create a favorable situation so that the total capacity of Yenisey plant may be about 6,000 mw. The energy of this powerplant is planned to be transmitted to the Ural industrial area.

5. Osinovo powerplant is another possible powerplant on Yenisey River with a total capacity of 2,000 mw.



Drainage Area	=	2 700 000 KM^2
Reservoir Capacity	=	30 Billion M^3
Total Head	=	1 600 Meters
Total Installed Capacity	=	19 200 M.W.
KWH/year	=	120 Billion

CASCADE DIAGRAM OF YENISEY RIVER

It is anticipated that the powerplants on Angara and Yenisey Rivers will be tied in a single system by means of 500 kv transmission lines when they are completed.

OB RIVER SYSTEM

The Ob River is 3,676 km long. Its drainage area is 2,930,000 km². The total head of 165 meters may be used by 10 hydro powerplants enumerated below. The possible annual energy generation is estimated to be 50 billion kwh and the total capacity approximately 11,850 mw.

Economically, the most desirable powerplants are as follows:

1. Kamen' powerplant is now in the design stage. The dam at this plant will be 6 km long. The dam will be constructed of earth 35 meters high with two concrete navigation locks. Openings in the powerhouse foundation will serve as bottom spillways. The total reservoir capacity of this plant is expected to be 54 billion m³. The annual energy generation will be 2.6 billion kwh. The head will be 54 meters.

The construction of Kamen' plant will solve the problem of through navigation between cities of Barnaul and Novosibirsk and also will enable irrigation of 650,000 hectares of land.

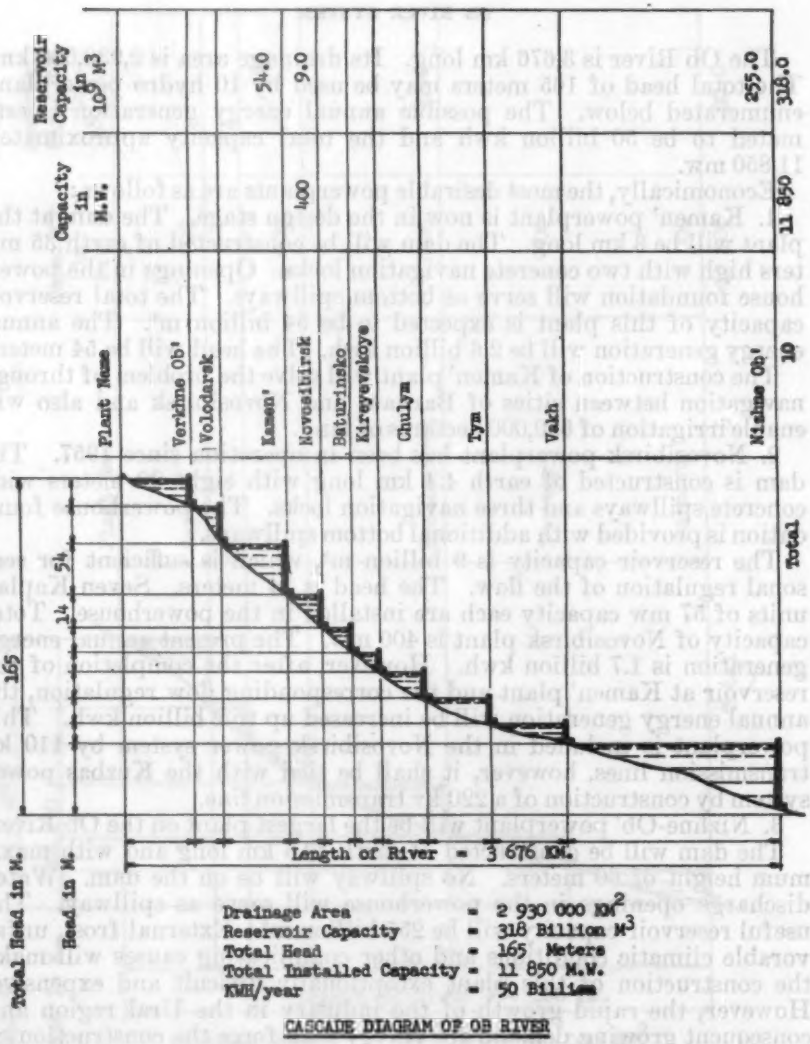
2. Novosibirsk powerplant has been in operation since 1957. The dam is constructed of earth 4.4 km long with eight 20 meters wide concrete spillways and three navigation locks. The powerhouse foundation is provided with additional bottom spillways.

The reservoir capacity is 9 billion m³, which is sufficient for seasonal regulation of the flow. The head is 14 meters. Seven Kaplan units of 57 mw capacity each are installed in the powerhouse. Total capacity of Novosibirsk plant is 400 mw. The present annual energy generation is 1.7 billion kwh. However, after the completion of the reservoir at Kamen' plant and the corresponding flow regulation, the annual energy generation will be increased up to 2 billion kwh. This powerplant is included in the Novosibirsk power system by 110 kv transmission lines, however, it shall be tied with the Kuzbas power system by construction of a 220 kv transmission line.

3. Nizhne-Ob' powerplant will be the largest plant on the Ob River. The dam will be constructed of earth 12.5 km long and with maximum height of 60 meters. No spillway will be on the dam. Water discharge openings in the powerhouse will serve as spillway. The useful reservoir capacity will be 255 billion m³. External frost, unfavorable climatic conditions and other complicating causes will make the construction of this plant exceptionally difficult and expensive. However, the rapid growth of the industry in the Ural region and consequent growing demand for energy may force the construction of the Nizhne Ob' plant. For transmission of energy to the Ural region at a distance of 1,500 km the transmission line is planned to be of 1,200 kv d.c. (±600 kv) or above 500 kv a.c.

4. Baturinskaya powerplant is considered as possible for construction if the energy demand in the industrial region of Novosibirsk increases.

The following plants planned in the cascade are of less value because the construction of these plants with low head (8–16 m) will require



CASCADE DIAGRAM OF OB RIVER

very long dams and construction work under most adverse natural conditions:

1. Verkhne-Ob' powerplant
2. Volodarsk powerplant
3. Kireyevskoye powerplant
4. Chulym powerplant
5. Tym powerplant
6. Vakh powerplant

IRTYSH RIVER SYSTEM

The Irtysh River is 3,636 km long and empties into the Ob' River. The cascade of plants on the Irtysh River is intended to consist of 16 powerplants with a total capacity of 4,500 mw, using a total head of 345 meters. The total annual energy generation is estimated to be 19 billion kwh.

The following three powerplants are the largest and most desirable from a standpoint of economy:

1. Bukhtarma powerplant has been under construction since 1953, with some of the units now in operation. The concrete dam up to 90 meters high, 430 meters long, with three navigation locks, and three 18-meter-wide spillways will create a carryover reservoir with useful capacity of 31 billion m^3. This reservoir enables flow regulation over a period of years. The head is 65 meters. Seven Kaplan units of 72 mw capacity each will be installed in the powerhouse. The total capacity of the plant will be 500 mw with an annual energy generation of 2.5 billion kwh. The generator rated voltage is 13.8 kv.

Outdoor substations are 110 and 220 kv.

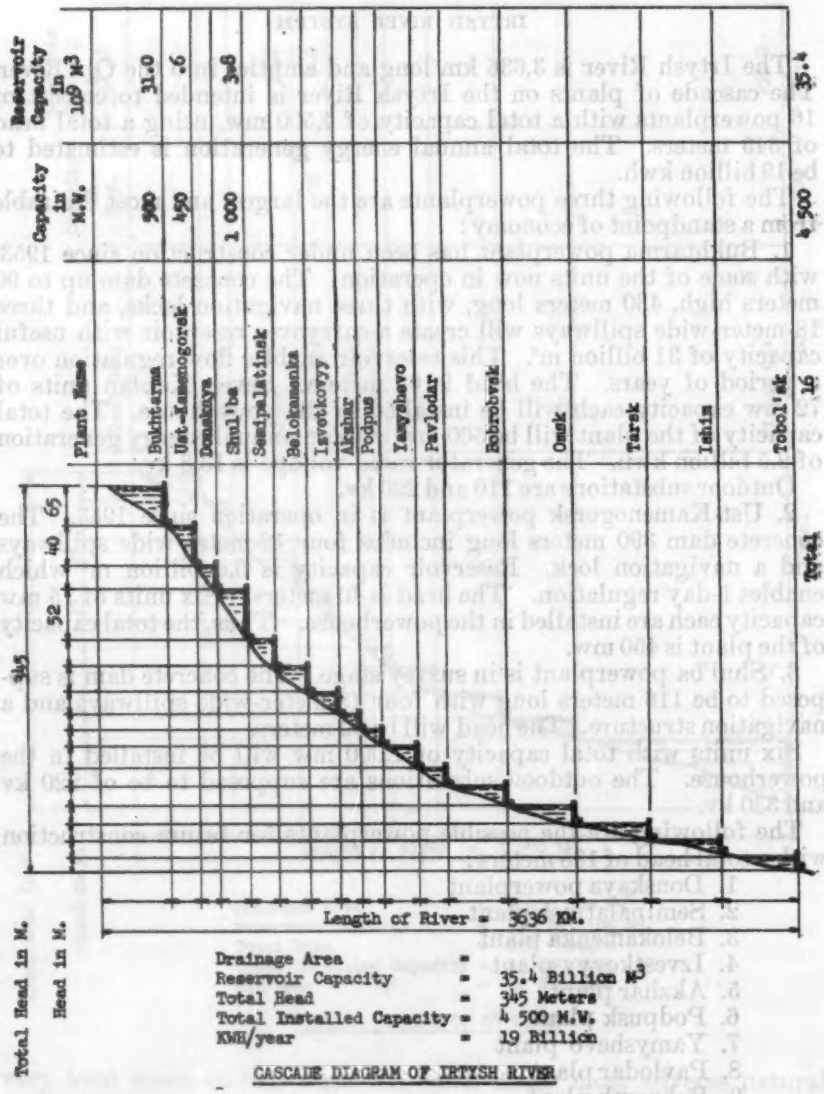
2. Ust-Kamenogorsk powerplant is in operation since 1953. The concrete dam 390 meters long includes four 18-meter-wide spillways and a navigation lock. Reservoir capacity is 0.6 billion m^3 which enables 1-day regulation. The head is 40 meters. Six units of 75 mw capacity each are installed in the powerhouse. Thus, the total capacity of the plant is 450 mw.

3. Shul'ba powerplant is in survey stage. The concrete dam is supposed to be 116 meters long with four 18-meter-wide spillways and a navigation structure. The head will be 52 meters.

Six units with total capacity of 1,000 mw will be installed in the powerhouse. The outdoor substations are supposed to be of 220 kv and 330 kv.

The following are the possible powerplants for future construction with a total head of 188 meters:

1. Donskaya powerplant
2. Semipalatinsk plant
3. Belokamenka plant
4. Izvestkovyy plant
5. Akzhar plant
6. Podpusk plant
7. Yamyshevo plant
8. Pavlodar plant
9. Bobrovsk plant
10. Omsk plant
11. Tarsk plant
12. Ishim plant
13. Tobol'sk plant

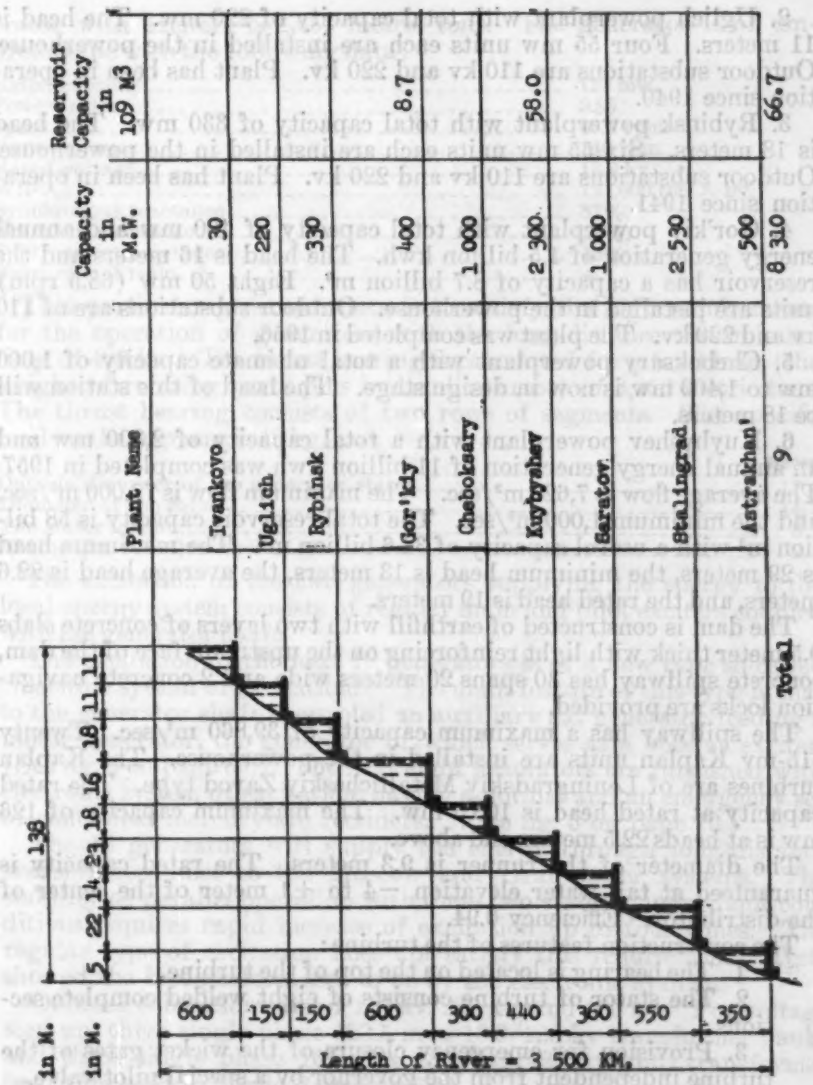


CASCADE DIAGRAM OF IRTYSH RIVER

VOLGA RIVER SYSTEM

The Volga is one of the largest rivers in Europe. Its drainage area, upstream from Kuybyshev only, is 1,200,000 km.²

The source of the Volga is in Valdai Hills and it empties into the Caspian Sea. The Volga is the main waterway of the European part of the U.S.S.R. The following nine hydropower plants with a total capacity above 8.300 mw are installed or proposed.



CASCADE DIAGRAM OF VOLGA RIVER

1. Ivankovo powerplant with total capacity of 30 mw. The head is 11 meters. Two 15 mw units are installed in the powerhouse. The plant has been in operation since 1937.

2. Uglich powerplant with total capacity of 220 mw. The head is 11 meters. Four 55 mw units each are installed in the powerhouse. Outdoor substations are 110 kv and 220 kv. Plant has been in operation since 1940.

3. Rybinsk powerplant with total capacity of 330 mw. The head is 18 meters. Six 55 mw units each are installed in the powerhouse. Outdoor substations are 110 kv and 220 kv. Plant has been in operation since 1941.

4. Gor'kiy powerplant with total capacity of 400 mw and annual energy generation of 1.5 billion kwh. The head is 16 meters and the reservoir has a capacity of 8.7 billion m^3. Eight 50 mw (68.5 rpm) units are installed in the powerhouse. Outdoor substations are of 110 kv and 220 kv. The plant was completed in 1956.

5. Cheboksary powerplant with a total ultimate capacity of 1,000 mw to 1,400 mw is now in design stage. The head of this station will be 18 meters.

6. Kuybyshev powerplant with a total capacity of 2,300 mw and an annual energy generation of 11 billion kwh was completed in 1957 The average flow is 7,620 m^3/sec. The maximum flow is 72,000 m^3/sec. and the minimum 1,000 m^3/sec. The total reservoir capacity is 58 billion m^3 with a useful capacity of 34.6 billion m^3. The maximum head is 29 meters, the minimum head is 13 meters, the average head is 22.6 meters, and the rated head is 19 meters.

The dam is constructed of earthfill with two layers of concrete slabs 0.5 meter thick with light reinforcing on the upstream face of the dam, concrete spillway has 30 spans 20 meters wide and 2 concrete navigation locks are provided.

The spillway has a maximum capacity of 39,860 m^3/sec. Twenty 115-mv Kaplan units are installed in the powerhouse. The Kaplan turbines are of Leningradskiy Metallicheskiy Zavod type. The rated capacity at rated head is 108.5 mw. The maximum capacity of 126 mw is at heads 22.5 meters and above.

The diameter of the runner is 9.3 meters. The rated capacity is guaranteed at tail water elevation -4 to $+1$ meter of the center of the distributor. Efficiency 0.94.

The construction features of the turbine:

1. The bearing is located on the top of the turbine.
2. The stator of turbine consists of eight welded complete sections.
3. Provision for emergency closure of the wicket gates of the turbine independent from the governor by a special pilot valve.
4. Individual hydraulic drive for each wicket gate of the turbine.
5. The weight of the turbine is 1,550 metric tons.

The location of the thrust bearing below the generator decreased the overall height of the unit to 26.5 meters. The provision of independent emergency closing and the individual drive of wicket gates of the turbine simplifies the overspeed protection at runaway and has eliminated the automatically fast-closing gates before the turbine.

The turbines are provided with a double governing system. The generators are of the Zavod "Electrosila" type. The weight of gen-

erator with exciters is 1,650 metric tons. The generator is of umbrella type with the following data:

Rated capacity	115 mw.
Power factor	0.85.
Speed	68.2 rpm.
Runaway speed	140 rpm.
Rated voltage	13.8 kv.
WR^2	121,000 ton × m^2.
Synchronous reactance	57%.
Transient reactance	20%.
Subtransient reactance	15%.
Short circuit ratio	4.

This particular generator data is to satisfy the high requirements for the operation of generators with the long-distance transmission lines of 400 kv. The thrust bearing is calculated for a total load (the weight of rotating parts plus hydraulic thrust) of 3,250 metric tons. The thrust bearing consists of two rows of segments. The specific load on the segment is 40 kg/cm^2.

	Meters
Outside diameter of the generator stator	17.1
Diameter of the rotor	14.3
The stator height	3.4
The height of active steel	2.0

The excitation of the two generators supplying the energy to the local energy system consists of regular main and pilot exciters coupled with the generator shaft.

The excitation of the next 10 generators is of a new type so-called "machine system of excitation." The main feature of this type is that to the generator shaft is coupled an auxiliary a.c. generator feeding a motor generator, the generator of which serves as a booster exciter. (See fig. 2 on page 69.) The next eight generators are furnished with electronic system of excitation, having a normal and an emergency set of controlled mercury-arc rectifiers. (See fig. 3 on page 70.)

The 18 generators will supply the energy through long-distance transmission lines to the Moscow and Ural power systems. The stability of parallel operation with these two systems under fault conditions requires rapid increase of excitation up to four times. The regular type of excitation does not satisfy this requirement. Tests showed the best performance to be by the electronic system.

Outdoor substations are of 110 kv, 220 kv, and 400 kv. For voltage step-up, three single-phase 123.5 mva 13.8/420 kv transformer banks and three single phase 167 mva 13.8/242/420 kv auto transformer banks are used. (See fig. 1 on page 68.)

The primaries of the transformers and auto transformers are of two or three electrically separate windings, depending on the number of generators united in a single block. All transformers and auto transformers having secondary windings of 220 kv, are furnished with ± 10 percent load ratio control of the windings.

The present capacity of transformers and auto transformers does not match with the capacity of the generators; therefore, it is planned in the near future to change the 400 kv windings of these transformers to 500 kv windings when the 400-kv Kuybyshev-Moscow transmission lines are converted to 500 kv.

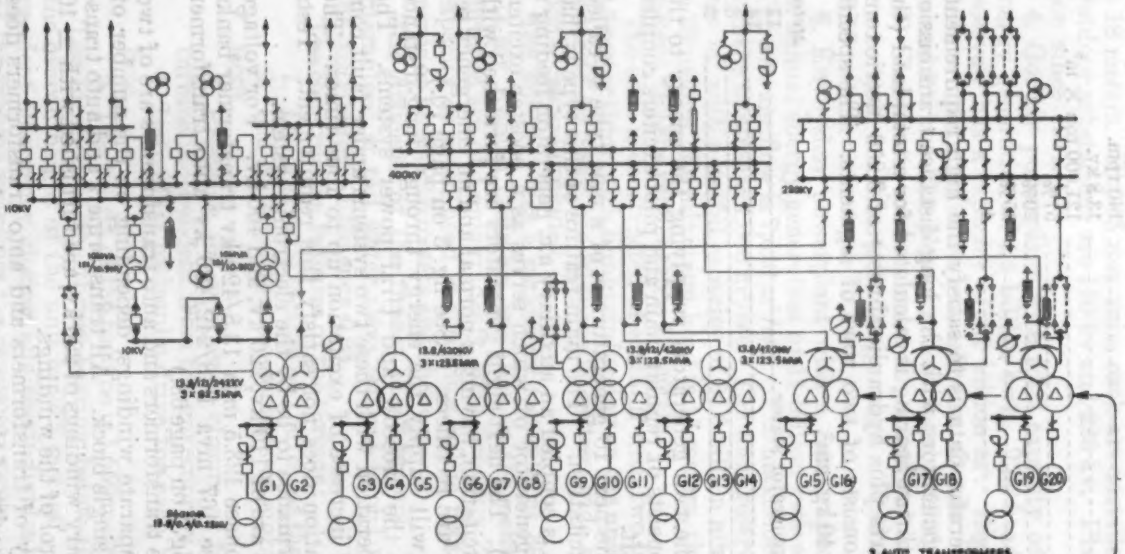


FIG. 1 ELECTRICAL SINGLE LINE DIAGRAM OF KUYBYSHEV POWER PLANT

(G1)	Generator No. 1		Disconnect switch
	Two winding transformer		Reactor
	Multi winding transformer		Underground cable
	Circuit breaker		Lightning arrester

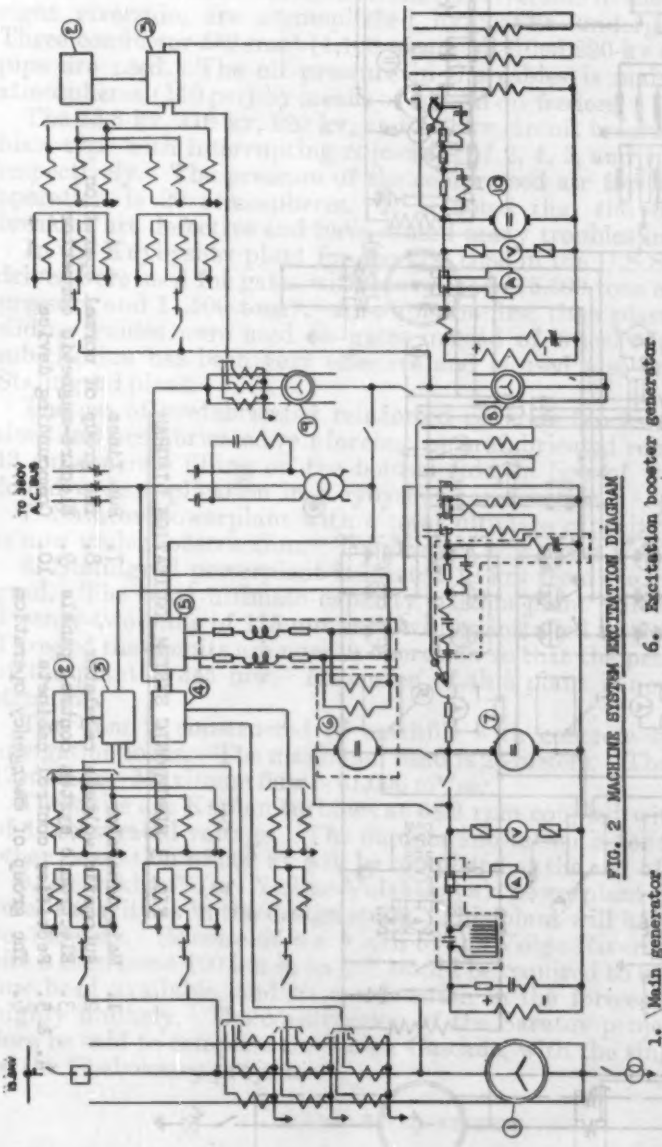


FIG. 2 MACHINE SYSTEM EXCITATION DIAGRAM

1. Main generator
2. Electro magnetic corrector
3. Compounding device
4. Metering and control of electronic regulator of excitation
5. Power supply of electronic regulator of excitation
6. Excitation booster generator
7. Main generator exciter
8. Auxiliary generator
9. Drive motor for booster generator
10. Auxiliary generator exciter

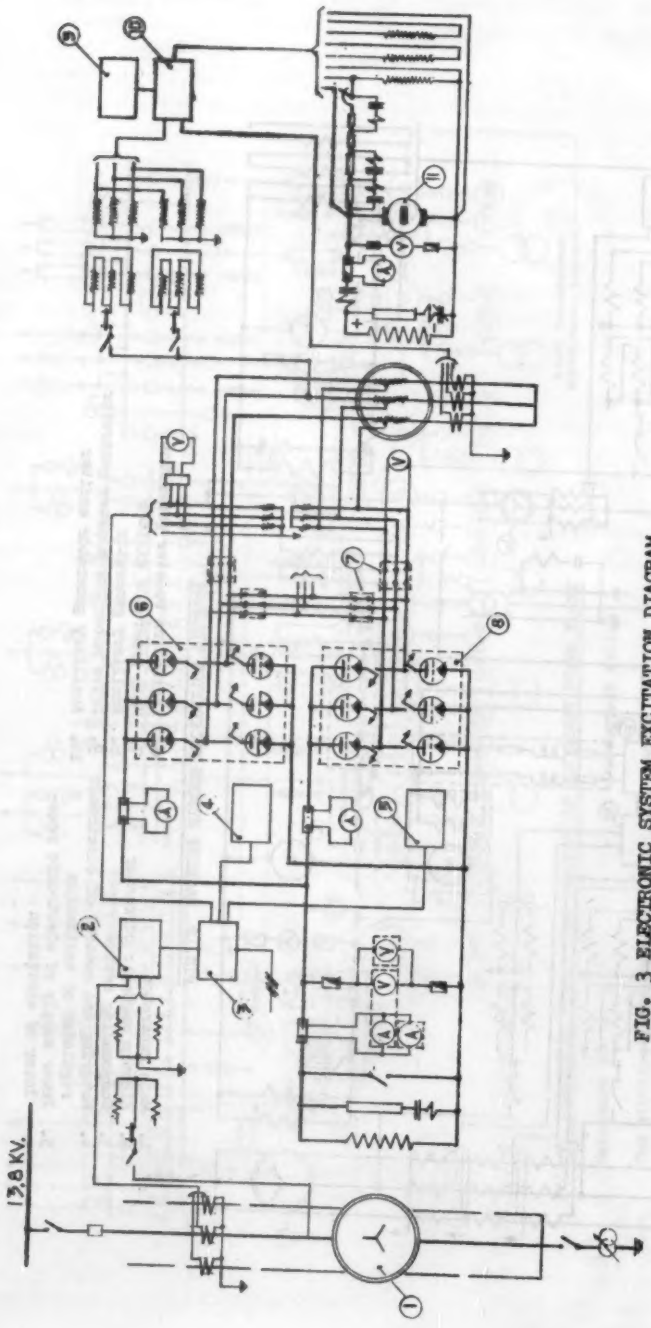


FIG. 3 ELECTRONIC SYSTEM EXCITATION DIAGRAM

1. Main Generator
2. Automatic voltage regulator
3. Electronic system control panels
4. & 5. Rectifier control cabinets
6. The group of emergency operation
7. Bus Lines
8. The group of normal operation
9. Electro-magnetic corrector
10. Compounding device

For compensation of line capacitance to keep the 400-kv bus voltage in required range, shunt reactors for each 400-kv line are provided. These reactors are connected to the lines through circuit breakers. The 220-kv transformer leads to 220-kv bus and the 220-kv outgoing line leads, from the substation on the left riverside to the towers on the right riverside, are accomplished by 220-kv underground cables. Three conductor 550 mm² (1,100 mem) oil-filled 220-kv cables in steel pipe are used. The oil pressure in the cables is maintained at 15 atmospheres (140 psi) by means of special oil feeders.

The 13.8 kv, 110 kv, 220 kv, and 400 kv circuit breakers are of air-blast type with interrupting capacities of 2, 4, 5, and 15 million kva, respectively. The pressure of the compressed air for circuit breaker operation is 20 atmospheres. It is noted that the 400 kv circuit breakers are defective and have caused many troubles in operation.

In the Kuybyshev plant for the first time in the U.S.S.R. hydraulic drives were used for gates with heavy loads (5,300 tons of hydrostatic pressure and 11,500 tons). Also for the first time plastic (lignofol) sliding guides were used on gates instead of wheel supports. This substitution has been very effective and is used also on all gates of Stalingrad plant.

The use of prefabricated reinforced concrete blocks and constructions and prefabricated reinforcing, or prefabricated reinforcing with 13 cm concrete filling on the bottom side, in lieu of wooden forms, found wide application in Kuybyshev construction.

7. Saratov powerplant with a total ultimate capacity of 1,000 mw is now under construction. The head of this plant will be 14 meters.

8. Stalingrad powerplant is located 12 km from the city of Stalingrad. The total ultimate capacity of this plant will be 2,530 mw. Twenty-two units of 115 mw each will be installed in the powerhouse. Three of these units are now in operation so that the present capacity of the plant is 345 mw. Extension of this plant is now under construction.

The dam is constructed of earthfill with concrete spillway with navigation locks. The maximum head is 26 meters. The minimum is 17 meters. Maximum flow is 61,000 m³/sec.

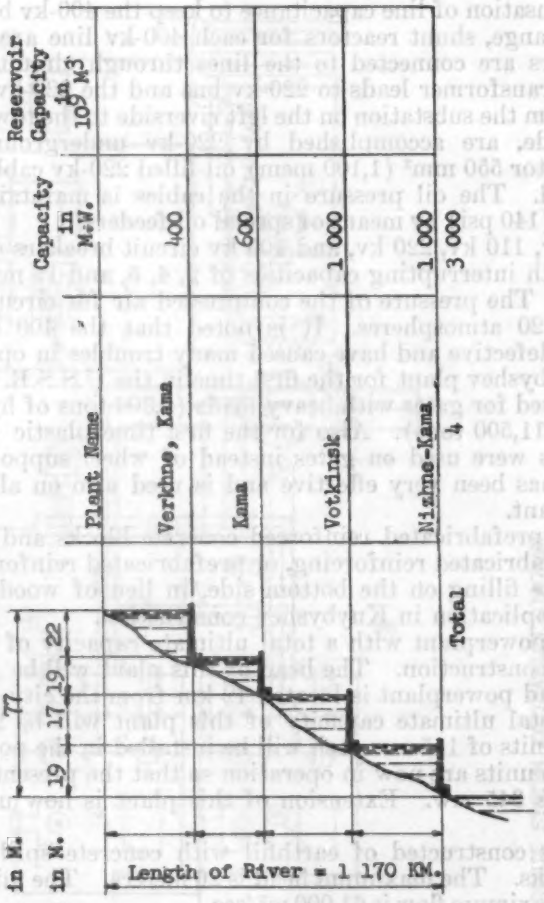
The units are Kaplan turbines at 68.2 rpm coupled with generators of 13.8-kv-rated voltage. The outdoor substation is for 220 kv. Another substation of 500 kv will be completed at the end of 1959.

9. Astrakhan' (or Nizhne-Volzhskaya) powerplant with 500 mv total capacity is in the design stage. This plant will have a head of 4 to 5 meters. Because of the width of the Volga River Valley at this site a dam some 120 km in length would be required to utilize the very low head available, and its construction in the foreseeable future is highly unlikely. The construction of the Saratov project can therefore be said to complete the Volga Cascade, with the single exception of the Cheboksary project.

KAMA RIVER SYSTEM

The Kama River is the largest tributary of the Volga River. Four powerplants are planned on this river with a total capacity of 3,000 mw. The powerplants are as follows:

1. Verkhne-Kama powerplant with total capacity of 400 mw is planned for the future with a head of 22 meters.



Drainage Area =
Reservoir Capacity =
Total Head = 77 Meters.
Total Installed Capacity = 3 000 M.W.
KWH/year =

CASCADE DIAGRAM OF KAMA RIVER

2. Kama (Perm') powerplant with a total capacity of 600 mw is in operation. The head is 19 meters. The powerhouse of this plant is located in the body of the dam, thereby eliminating the construction of a separate powerhouse.

3. Votkinsk powerplant with total ultimate capacity of 1,000 mw is under construction. The head is 17 meters.

4. Nizhne-Kama powerplant with a head of 19 meters and total ultimate capacity of 1,000 mw is in design stage.

VOLGA-DON CANAL—TSIMLYANSK PLANT

Tsimlyanskaya powerplant is constructed on the Don River end of the Volga-Don Canal 150 km from the city of Rostov-on-Don. It has been in operation since 1952. The total capacity of the plant is 164.2 mw with 0.6 to 1 billion kwh energy generation annually.

The dam is earth fill and it creates a head of 23.5 meters and a reservoir with total capacity of 23.5 billion m^3, of which the useful capacity is 12.5 billion m^3. There are two locks for navigation.

Four Kaplan units of 40 mw (88.2 rpm) each and one 4.2 mw unit are installed in the powerhouse. The main generator-rated voltage is 10.5 kv. Outdoor substations are of 110 kv and 220 kv.

DNIEPER RIVER SYSTEM

The Dnieper is 2,285 km long and its average annual flow is 53 billion m^3. Its drainage area is 500,000 km^2.

It is planned to have 14 hydro powerplants located along the entire length of the river. The total capacity of these plants will be 3,300 mw with annual energy generation of 10.4 billion kwh.

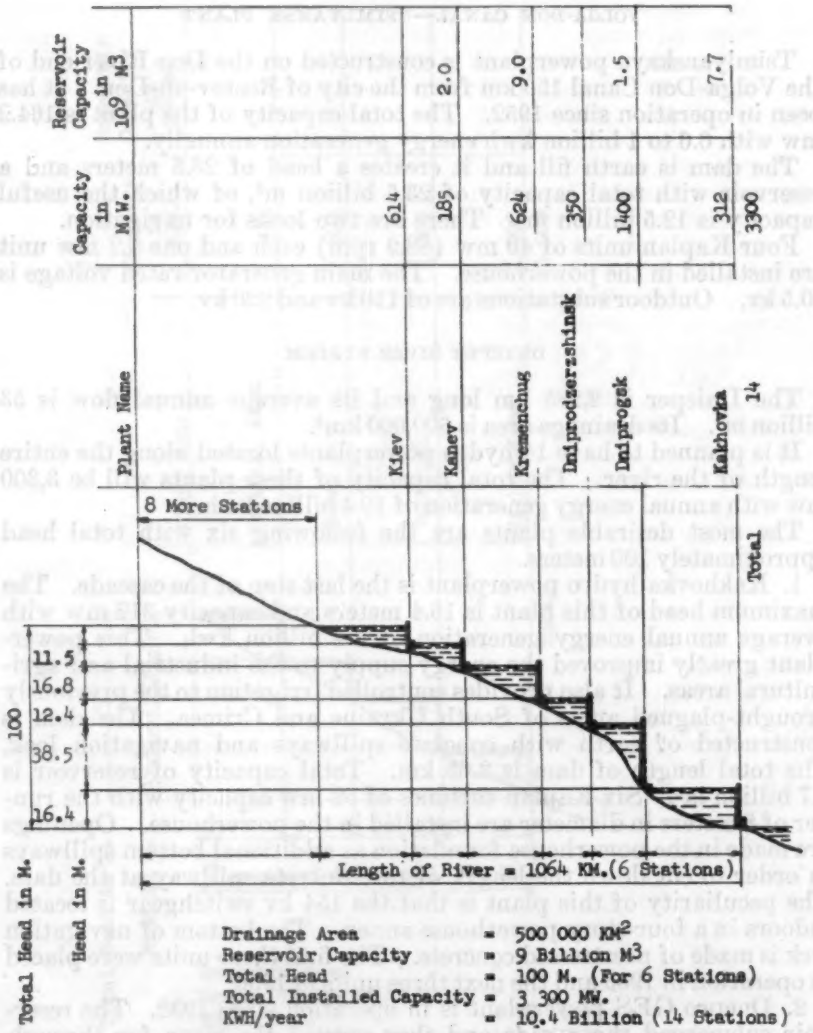
The most desirable plants are the following six with total head approximately 100 meters.

1. Kakhovka hydro powerplant is the last step of the cascade. The maximum head of this plant is 16.4 meters and capacity 312 mw with average annual energy generation of 1.4 billion kwh. This powerplant greatly improved the energy supply to the industrial and agricultural areas. It also provides controlled irrigation to the previously drought-plagued areas of South Ukraine and Crimea. The dam is constructed of earth with concrete spillways and navigation lock. The total length of dam is 3.65 km. Total capacity of reservoir is 7.7 billion m^3. Six Kaplan turbines of 52 mw capacity with the runner of 8 meters in diameter are installed in the powerhouse. Openings are made in the powerhouse foundation as additional bottom spillways in order to cut down the length of the concrete spillway at the dam. The peculiarity of this plant is that the 154 kv switchgear is located indoors in a four-story powerhouse annex. The bottom of navigation lock is made of prestressed concrete. The first three units were placed in operation in 1955 and the next three units in 1956.

2. Dnepro GES powerplant is in operation since 1932. The reservoir submerged the rapids and thus opened the river for through navigation. The reservoir capacity is 1.5 billion m^3. The capacity of the plant is 650 mw with average annual energy generation of 3.1 billion kwh. The concrete dam 760 meters long includes the spillway (47 openings of 13 meter width) and three navigation locks. The maximum head is 38.5 meters.

After the completion of the Kremenchug powerplant, the energy generation of Dnepro GES will increase up to 3.6 billion kwh. Nine units of radial flow type 72 mw each are installed in powerhouse.

It is considered advisable to increase the capacity of this station up to 1,400 mw using the future large reservoir at Kremenchug plant as a flow regulator. In order to increase the powerplant capacity, an additional six units at 125 mw will be installed in a separate powerhouse. Outdoor substations are of 154 kv and 220 kv.



CASCADE DIAGRAM OF DNIEPER RIVER

3. Dniprodzerzhinsk powerplant is under construction and is located on outskirts of the city of Dniprodzerzhinsk.

The dam is of earth fill and includes concrete spillway (10 openings of 16 meter width) and navigation lock. The head is 12.4 meters. Total capacity is 350 mw with average annual energy generation of 1.25 billion kwh. Eight units of 43 mw each of Kaplan type will be installed outdoors. This plant will have reservoir capacity sufficient only for 1 day regulation, however, the surrounding land will be protected by an earth-filled dam 29 km long.

4. Kremenchug powerplant is under construction and will be of 624 mw capacity. The maximum head is 16.8 meters. The annual energy generation will be 1.5 billion kwh.

The significance of this station in the cascade is determined by the regulating capabilities of its reservoir. The useful capacity of the reservoir is 9 billion m^3, which enables flood control and the annual regulation of the flow for Kremenchug plant and for all other plants located on lower parts of the river. The Dnieper will be navigable for large ships from the city of Kanev to the Black Sea.

The dam is of earth fill and includes concrete spillway and navigation lock. The total length of dam is 12 km. The 12 Kaplan units of 52 mw capacity each will be installed outdoors. The three-phase generators will be provided with electronic excitation. Outdoor substations will be of 154 kv and 330 kv.

5 and 6. Kanev and Kiev powerplants are in design stage.

The construction of the Kanev powerplant is important also for navigation since it will enable through navigation for large ships from Kiev to the Black Sea. For construction of these two plants it is intended to use prefabricated concrete up to 60 percent. The head of Kanev is planned to 11.5 meters with useful capacity of reservoir to be 2 billion m^3. The installed capacity will be 185 mw with annual energy generation of 813 million kwh.

7. The future possible eight plants are not yet designed.

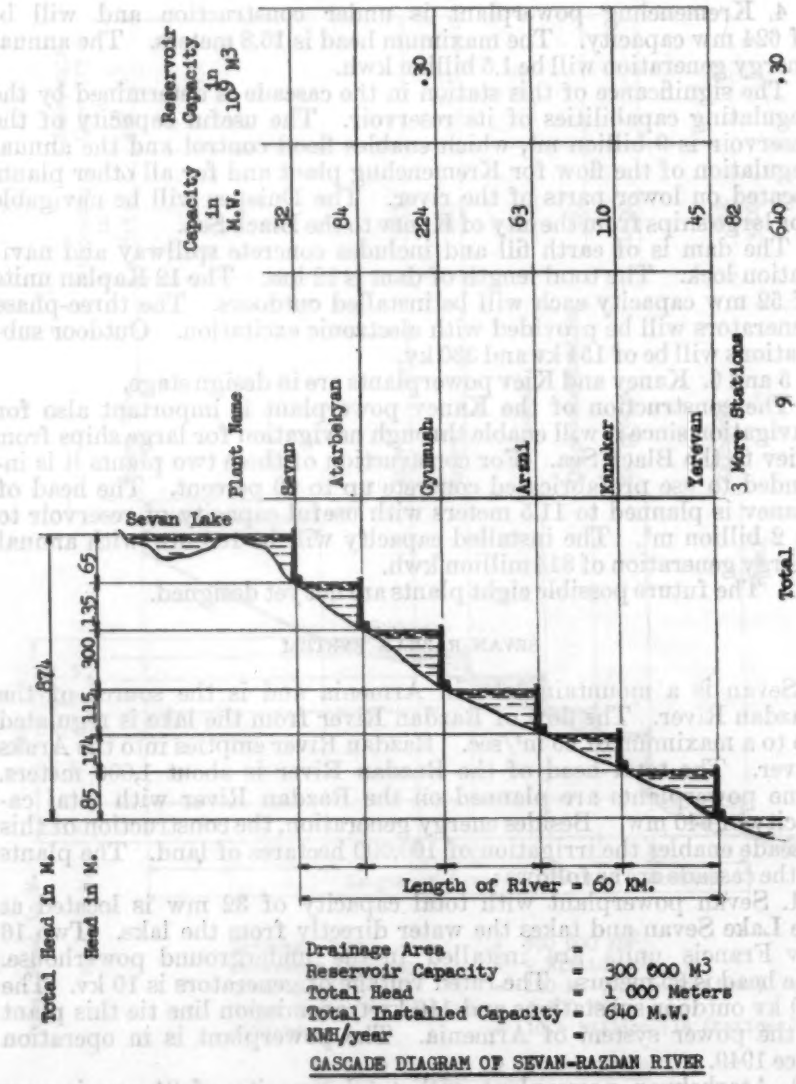
SEVAN-RAZDAN SYSTEM

Sevan is a mountain lake in Armenia and is the source of the Razdan River. The flow of Razdan River from the lake is regulated up to a maximum of 65 m^3/sec. Razdan River empties into the Araks River. The total head of the Razdan River is about 1,000 meters. Nine powerplants are planned on the Razdan River with total capacity of 640 mw. Besides energy generation, the construction of this cascade enables the irrigation of 160,000 hectares of land. The plants of the cascade are as follows:

1. Sevan powerplant with total capacity of 32 mw is located at the Lake Sevan and takes the water directly from the lake. Two 16 mw Francis units are installed in the underground powerhouse. The head is 65 meters. The rated voltage of generators is 10 kv. The 110 kv outdoor substations and 110 kv transmission line tie this plant to the power system of Armenia. The powerplant is in operation since 1949.

2. Atarbekyan powerplant with total capacity of 84 mw is now under construction and is planned to be placed in operation at the end of 1959. The concrete dam with spillway will create a head of 135 meters. Penstock of 3.5 meters in diameter will be provided for two Francis units at 42 mw each, installed in powerhouse. The generator rated voltage is 10 kv. The 110 kv substation and 110 kv transmission line will tie the plant with the power system of Armenia.

3. Gyumush powerplant with total capacity of 224 mw has been in operation since 1953. The concrete dam with spillway creates a head of 300 meters and a reservoir with a capacity of 300,000 m^3. Four 56 mw units are installed in the powerhouse. Four penstocks serve the



CASCADE DIAGRAM OF SEVAN-RAZDAN RIVER

turbines. The generator rated voltage is 10 kv. The 110 kv substation and 110 kv transmission lines tie the plant to the power system of Armenia.

4. Arzni powerplant with total capacity of 63 mw has been in operation since 1956. The concrete dam with spillway creates a head of 115 meters. Three Francis units at 21 mw each are installed in an underground powerhouse. Generator voltage is 10 kv. A 110 kv outdoor substation and 110 kv transmission lines tie the plant to the power system of Armenia.

5. Kanaker powerplant with total capacity of 110 mw has been in operation since 1937. The concrete dam with spillway creates a head of 174 meters. A 12 km long canal, 3 km long tunnel with a capacity of 65 m^3/sec., and 4 penstocks serve the powerplant. Two Francis units at 25 mw each and 4 units at 15 mw each are installed in the powerhouse. Outdoor substations are of 35 kv and 110 kv; 35 kv lines transmit the energy to the city of Yerevan and the 110 kv tie the plant to the power system of Armenia.

6. Yerevan powerplant with total capacity of 45 mw will be constructed near the city of Yerevan. The head will be 85 meters. Two units at 22.5 mw each will be installed in the powerhouse. A 110 kv outdoor substation will tie the plant with the power system of Armenia.

7. Three more plants are planned on the Razdan River with a total head of 126 meters and total capacity of 82 mw.

KHRAMI RIVER SYSTEM

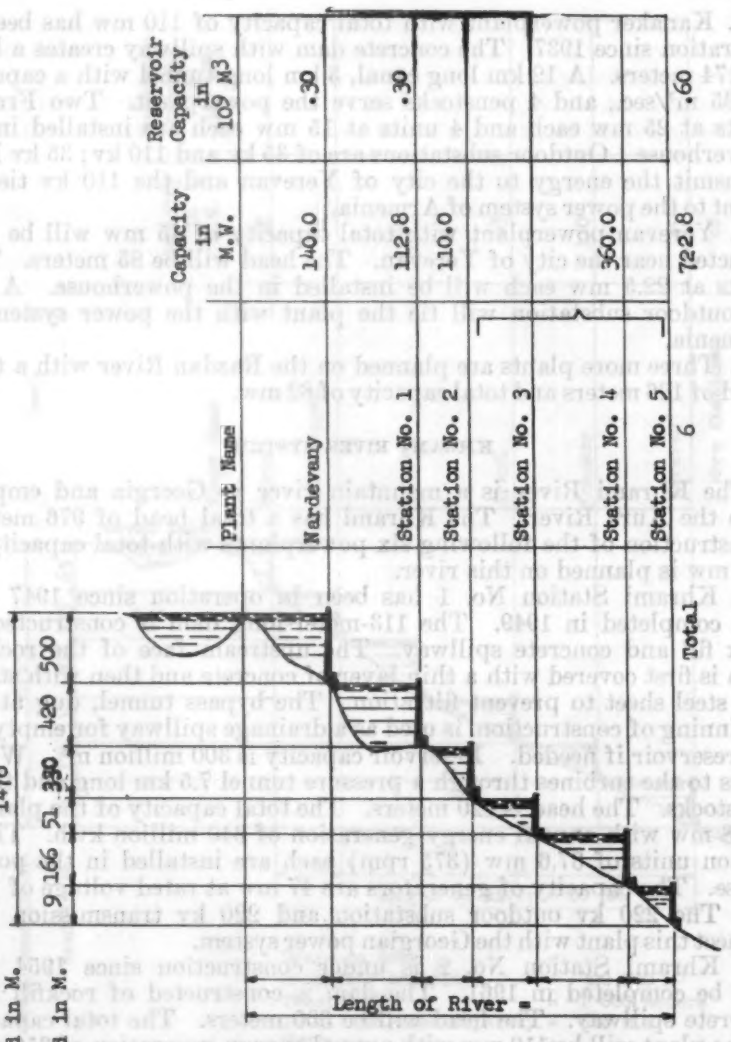
The Khrami River is a mountain river in Georgia and empties into the Kura River. The Khrami has a total head of 976 meters. Construction of the following six powerplants with total capacity of 723 mw is planned on this river.

1. Khrami Station No. 1 has been in operation since 1947 and was completed in 1949. The 113-meter-long dam is constructed of rock fill and concrete spillway. The upstream face of the rockfill dam is first covered with a thin layer of concrete and then with stainless steel sheet to prevent filtration. The bypass tunnel, dug at the beginning of construction, is used as a drainage spillway for emptying the reservoir if needed. Reservoir capacity is 300 million m^3. Water flows to the turbines through a pressure tunnel 7.5 km long and three penstocks. The head is 420 meters. The total capacity of the plant is 112.8 mw with annual energy generation of 340 million kwh. Three Pelton units of 37.6 mw (375 rpm) each are installed in the power house. The capacity of generators are 47 mw at rated voltage of 10.5 kv. The 220 kv outdoor substation and 220 kv transmission line connect this plant with the Georgian power system.

2. Khrami Station No. 2 is under construction since 1954 and will be completed in 1961. The dam is constructed of rockfill and concrete spillway. The head will be 330 meters. The total capacity of the plant will be 110 mw with annual energy generation of 350 million kwh. Two Pelton units of 55 mw each will be installed in the powerhouse. The 220 kv substation with 220 kv transmission line will be tied to the Georgian power system.

3. Three more powerplants are planned on the Khrami River with the heads of 51 meters, 166 meters, and 9 meters and total capacity of 360mw.

4. The construction of a pressure tunnel in the future is planned, connecting Lake Paravani with the reservoir of station No. 1 through another powerplant at Nardevani with a head of 500 meters. Two Pelton units of 70 mw each will be installed in the powerhouse of this plant. The total capacity of the plant will be 140 mw with annual



Drainage Area =
Reservoir Capacity = 600 Million M^3
Total Head = 1 476 Meters
Total Installed Capacity = 722.8 M.W.
KWH/year =

CASCADE DIAGRAM OF KHRAMI RIVER

energy generation of 280 million kwh. The reservoir capacity at the Nardevani plant will be a 300 million m^3. Thus the total number of powerplants of the cascade will be six with a total head of 1,476 meters.

KURA RIVER—ZA GES PLANT

Za GES powerplant has a total capacity of 36.8 mw and is located on the Kura River 15 km from Tbilisi (Georgia). The plant has been

in operation since 1927. The concrete dam with spillway creates a head of 23 meters. A 3 meter wide canal serves the powerplant. Four Francis units of 3.2 mw (214 rpm) each and two units of 12 mw (157 rpm) each are installed in the powerhouse. Outdoor substations are of 35 kv and 110 kv. A 220 kv substation is planned for the future.

MZYMTA RIVER SYSTEM

The Mzymta is a mountain river in Northern Caucasus. It is planned to construct the five following powerplants with a total capacity of 140 mw on this river.

1. Krasnaya Polyana powerplant with total capacity of 28 mw has been in operation since 1950. The plant is located 90 km from the city of Sochi. The dam of the plant is constructed of earthfill and creates a head of 110 meters. A 3-km-long canal and penstocks serve the four units of 7 mw (500 rpm) each installed in the powerhouse. The annual energy generation is 150 million kwh. The outdoor substation is of 110 kv.
2. Four more plants with total capacity of 112 mw are planned on this river. One of the future plants will be located upstream from the Kransnaya Polyana plant and the other three downstream.

SVIR RIVER SYSTEM

The Svir River flows from Onega Lake and empties into the Ladoga Lake. The two following powerplants are in operation on this river:

1. Svir powerplant No. 2 with a head of 14 meters and total capacity of 160 mw. Four units of 40 mw each are installed in the powerhouse. The plant was completed in 1952.
2. Svir powerplant No. 3 with a head of 10.5 meters and total capacity of 120 mw. Four units of 30 mw each are installed in the powerhouse. The plant was completed in 1932.

The Svir powerplant No. 1 constructed earlier was inundated by construction of powerplant No. 2.

NIVA RIVER SYSTEM

The Niva River flows into Kandalaksha Gulf (Beloye More). Three powerplants are constructed on this river, one with total capacity of 40 mw having a head of 20 meters, another with total capacity of 60 mw at a head of 35 meters, and the third plant with a total capacity of 150 mw at a head of 75 meters.

TULOMA RIVER—MURMANSK PLANT

The Murmansk hydropower plant is constructed on the Tuloma River near the city of Murmansk. The Tuloma River empties into the Arctic Ocean. The total capacity of the plant is 48 mw. Four units of 12 mw each are installed in the powerhouse.

VOLKHOV RIVER—VOLKHOV PLANT

The Volkhov powerplant is the first hydroplant constructed after the revolution and has been in operation since 1925. The total capacity of the plant is 64 mw. Eight units of 8 mw each are installed in the powerhouse.

ELECTRIC SERVICE TO URBAN AREAS IN THE SOVIET UNION

(By Alex Radin)

The most significant single factor with regard to the plans of the Soviet Union for supplying electric power to large urban areas is the Soviet Government's objective of having every city, with the exception of those in the "far north," connected to a regional grid system by 1965.

This objective was described to me in an interview which I had on October 9, 1959, with Mr. Georgi Serbinovski, of the state planning commission (Gosplan). The interview was arranged by the Ministry of Power Station Construction as a result of my request that I have an opportunity to talk with a responsible official having duties relating to the supply of electric power to urban areas.

Mr. Serbinovski said that the Russians have recognized, as we have, that economies in power supply point toward the use of larger and larger generating units, with cities connected to a regional and ultimately a national grid system.

As an indication of the economies that can be achieved through the construction of larger generating units, Mr. Serbinovski said that it has been estimated by Soviet officials that the cost per kilowatt of capacity of a 5,000-kilowatt thermal plant is about two and one-half to three times as much as the cost per kilowatt of capacity of a 200,000-kilowatt plant.

REGIONAL GRID SYSTEMS TO SERVE URBAN AREAS

The Soviet Union, he said, consequently has embarked upon a vigorous program of building larger and larger generating units, both thermal and hydro, with the generating units being interconnected through regional grid systems. (We had learned earlier, in our first meeting with the Ministry of Power Station Construction, that by 1965 the Russians hope to have five regional grid systems—European, Central Siberia, Northwest, Trans-Caucasian, and Middle Asian. Although it is not contemplated that all five of these grids will be interconnected during the current 7-year program, it is hoped that some will be joined together by transmission lines during this period, and it is planned that all of the regional grids will be interconnected ultimately.)

Substantial progress already has been made in the program of interconnecting urban areas to a grid system, Mr. Serbinovski stated. He contended that only 30 percent of the Russian cities are not now part of an interconnected power system. In the future, he said, isolated generating units will be installed in urban areas only under one

of two conditions: (1) Where small thermal plants are needed for producing process steam for heating or industrial purposes, or (2) for supplying power to industries that are in areas too remote to be connected to a grid system (an example of the latter situation being sugar processing plants). Isolated generating plants, primarily mobile oil-fired diesel units, also will continue to be used in some rural areas.

HYDRO POWER TO COST AS LITTLE AS ONE-HALF KOPECK PER KWH

The cost of generation from the large plants will be very low, according to Mr. Serbinovski. For example, the cost per kilowatt hour from a 2.4-million-kilowatt coal-fired steam plant now under construction in Siberia will be 3 kopecks per kilowatt-hour (at the tourist rate of exchange, this would be about 3 mills). The cost per kilowatt of installed capacity in this steam plant will be about 700 to 800 rubles (about $70 to $80 under the tourist rate of exchange). Cost of power at the damsite in some of the new hydro plants now under construction reputedly will be as low as one-half kopeck per kilowatt-hour.

In connection with the computations of the cost of power from these hydroelectric stations, it is significant to note that the dam structures are amortized over a 100-year period, with no interest or taxes being charged.

TRANSMISSION AT HIGHER VOLTAGE, LONGER DISTANCES

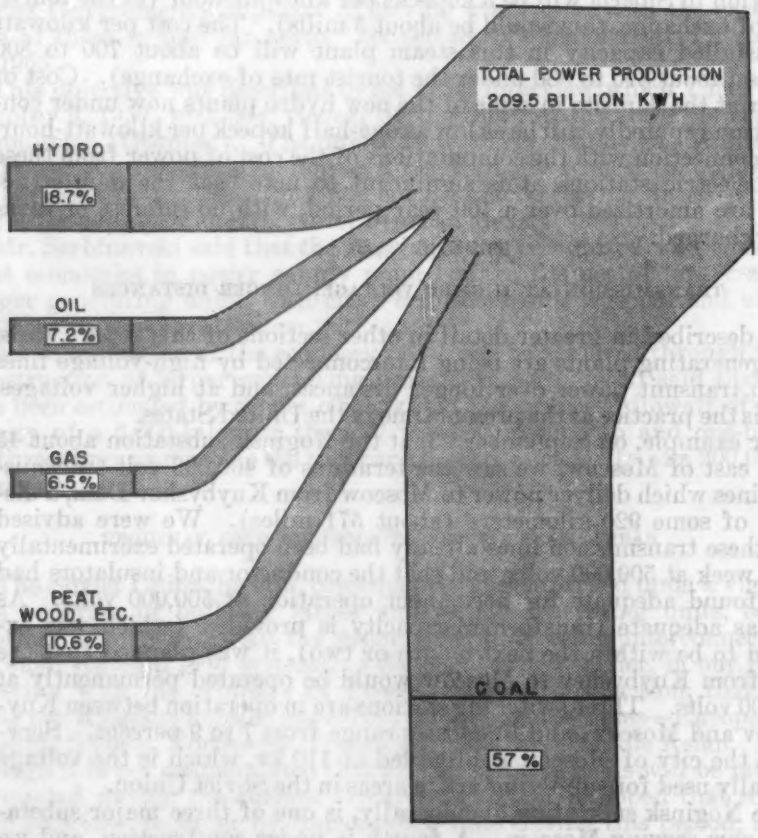
As described in greater detail in other sections of this report, these new generating plants are being interconnected by high-voltage lines which transmit power over longer distances, and at higher voltages, than is the practice at the present time in the United States.

For example, on September 23, at the Noginsk substation about 45 miles east of Moscow, we saw the terminus of 400,000-volt transmission lines which deliver power to Moscow from Kuybyshev Dam, a distance of some 920 kilometers (about 571 miles). We were advised that these transmission lines already had been operated exerimentally for 1 week at 500,000 volts, and that the conductor and insulators had been found adequate for permanent operation at 500,000 volts. As soon as adequate transformer capacity is provided (which was expected to be within the next month or two), it was planned that the lines from Kuybyshev to Moscow would be operated permanently at 500,000 volts. Three switching stations are in operation between Kuybyshev and Moscow, and line losses range from 7 to 9 percent. Service to the city of Moscow is provided at 110 kv, which is the voltage normally used for supplying urban areas in the Soviet Union.

The Noginsk substation, incidentally, is one of three major substations now serving Moscow. A fourth is under construction, and we were advised that the new substation will utilize 40 percent less steel than the existing substations, and only one building will be required, rather than the three which are needed for the Noginsk station.

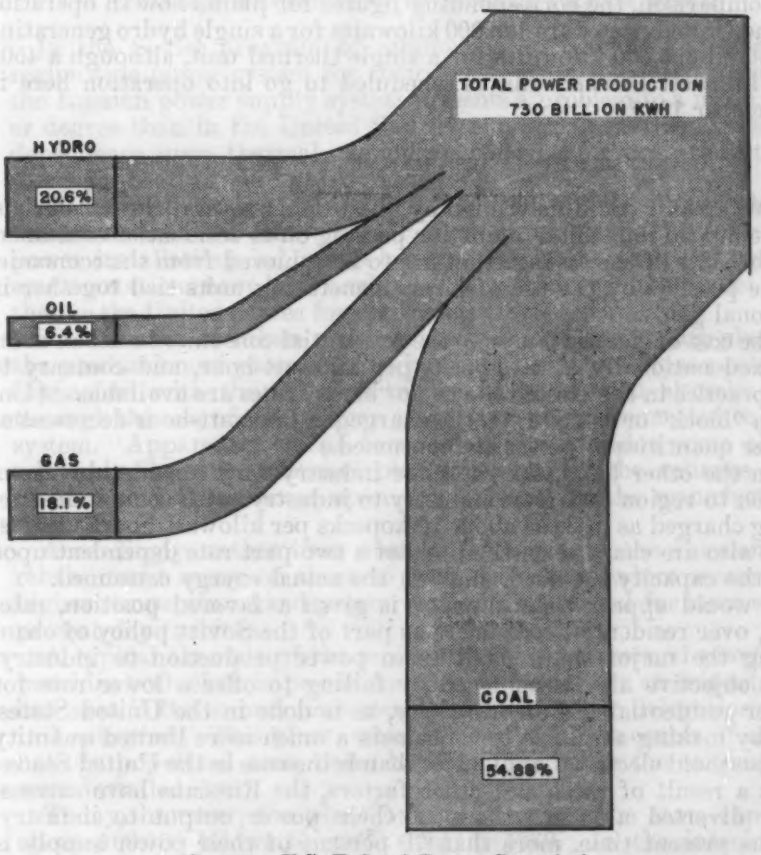
The 500,000 volts at which the Kuybyshev-Moscow transmission lines will be operated will not be unusual in the Soviet power system. It is also planned that the transmission lines from Stalingrad Dam to Moscow will be operated at 500,000 volts, as will the transmission facilities emanating from the large hydroelectric installations under construction in Siberia.

U.S.S.R.
SOURCES OF ENERGY FOR ELECTRIC POWER PRODUCTION
1957



Source: U.S.S.R. Ministry of Power-Station Construction.

UNITED STATES
SOURCES OF ENERGY FOR ELECTRIC POWER PRODUCTION
1957



Source: U.S. Federal Power Commission.

Moreover, as part of the program to integrate power facilities serving various urban areas, it is planned to expand the length of the transmission lines in the Soviet Union by three times during the course of the current 7-year plan, according to Mr. Serbinovski. This contrasts with an expansion of power capacity of slightly more than two times.

Although the objective of the Soviet Government during the current 7-year program is to build single units as large as 500,000 kilowatts for hydro stations and 300,000 kilowatts for thermal stations, the largest single generating unit now in operation in the Soviet Union is 115,000 kilowatts for hydro and 150,000 kilowatts for thermal plants. A 200,000-kw thermal unit is almost complete. (By way of comparison, the corresponding figures for plants now in operation in the United States are 108,000 kilowatts for a single hydro generating unit and 325,000 kilowatts for a single thermal unit, although a 450,000 kilowatt thermal unit is scheduled to go into operation here in December 1959.)

GOVERNMENT POLICIES CHANNEL POWER TO INDUSTRIES

As far as I could determine by questioning several Soviet officials, there are no immediate plans for passing on to residential consumers the benefits of the savings that are to be achieved from the economies made possible by the use of larger generating units tied together in regional grids.

The cost of electric power to the residential consumer in urban areas is fixed nationally at 40 kopeks per kilowatt-hour, and contrary to the practice in the United Staes, no "block" rates are available. (Under a "block" or "step" rate, the charge per kilowatt-hour decreases as larger quantities of power are consumed.)

On the other hand, the rates for industry vary considerably from region to region and from industry to industry, with some industries being charged as little as about 10 kopecks per kilowatt-hour. Industries also are charged on the basis of a two-part rate dependent upon (1) the capacity required, and (2) the actual energy consumed.

It would appear that industry is given a favored position, ratewise, over residential consumers as part of the Soviet policy of channeling the major share of Russian power production to industry. This objective also is achieved by failing to offer a lower rate for larger residential use of electricity, as is done in the United States, and by making available to consumers a much more limited quantity of household electrical appliances than is the case in the United States.

As a result of these and other factors, the Russians have successfully diverted a larger share of their power output to industry. At the present time, more than 79 percent of their power supply is used by industry, as compared with 49 percent of the U.S. power production. (It has been estimated that proportionately more and more electric power in the United States will be used by residential consumers in the future, and a correspondingly smaller share will be used by industry, with the percentage for industrial use dropping to 44 percent in 1975, according to Electrical World, a trade publication.)

Officials of the Soviet Ministry of Power Station Construction contend, however, that in the future they, too, intend to make more power available for residential consumers, as their industrial capacity is developed.

At our final meeting with the Minister and other officials of the Ministry of Power Station Construction, I commented that I had observed relatively little use of electric power by residential consumers, and the Minister, Mr. I. T. Novikov, acknowledged that this was true, but said that during the current 7-year program it was the objective of the Government to increase the amount of power used by residential consumers by 2.2 times.

THERMAL PLANTS USED TO PRODUCE PROCESS STEAM

In the Soviet program of attempting to provide an integrated, regionwide power system for their urban areas, one characteristic of the Russian power supply system presents a problem to a much greater degree than in the United States—namely, the rather widespread dependence upon thermal generating stations for the production of steam for heating and industrial uses.

Although I did not obtain any statistics on this subject, the conversations which I had with Mr. Serbinovski and other officials of power installations led me to believe that in the past, thermal generating stations have been used much more widely in the Soviet Union than in the United States for producing process steam.

The reliance of urban areas on these electric generating plants for the production of process steam presents a rather serious problem in connection with the effort to modernize the Soviet electric system through the use of new, larger generating plants connected to a grid system. Apparently it has been difficult to abandon some old and relatively inefficient thermal plants because of the reliance of industries and urban areas upon these plants for the manufacture of steam.

Accordingly, rather than abandon such plants, the Russians have rehabilitated many of them so that they can produce steam at the higher temperatures and pressures that are required for more efficient present-day turbines.

A typical example of the modernization of a thermal plant which provides both electric power and process steam for an important urban area is the second state steamplant which our delegation visited in Leningrad. This plant, which is located in the center of a rather heavily populated area, dates back to 1897, when the original units were installed.

Today, however, the plant has substantially the same capacity—about 100,000 kilowatts—as it had in 1930. In the interim, during World War II, some of the plant had to be disassembled and moved to a section of the country which was not threatened by the Nazi forces, but after the war a reconstruction program was initiated and today this plant is just as vital for the production of process steam for home heating as it is for the production of electric power.

According to the chief engineer, the plant is used today to heat 7.2 million cubic meters of building space (about 950 buildings), and 365 buildings are supplied with hot water from this plant.

The use of the installation for heating purposes and the consequent necessity to maintain steam lines requires a staff that would be considered abnormally large for an American steamplant of 100,000 kilowatts of capacity. For example, the second state steamplant at Leningrad has a total staff of 467 people, whereas, a new U.S. thermal plant of comparable capacity would probably have a staff of about 50 persons. However, comparisons of personnel requirements are most difficult, in view of the fact that the management of this Russian steamplant has the responsibility not only for maintaining steam lines but also for providing housing for many of the workers, as well as maintaining a kindergarten which has a staff of 18 in order to care for about 60 children.

The steamplant which we saw in Leningrad is a far cry from the new ones which are being planned for construction. At our final meeting with officials of the Ministry of Power Station Construction, the Minister showed us the drawing of a new steamplant which he said would be the model for several plants ranging in size from 1.2 million kilowatts to 2.4 million kilowatts. The Minister, Mr. Novikov, said that these new plants have been designed so efficiently that they will require little more than 40 percent of the area covered by some of the older steamplants, and will use only about 50 percent as much concrete. (Preformed concrete blocks will be used exclusively in the construction of the building housing the machine hall.)

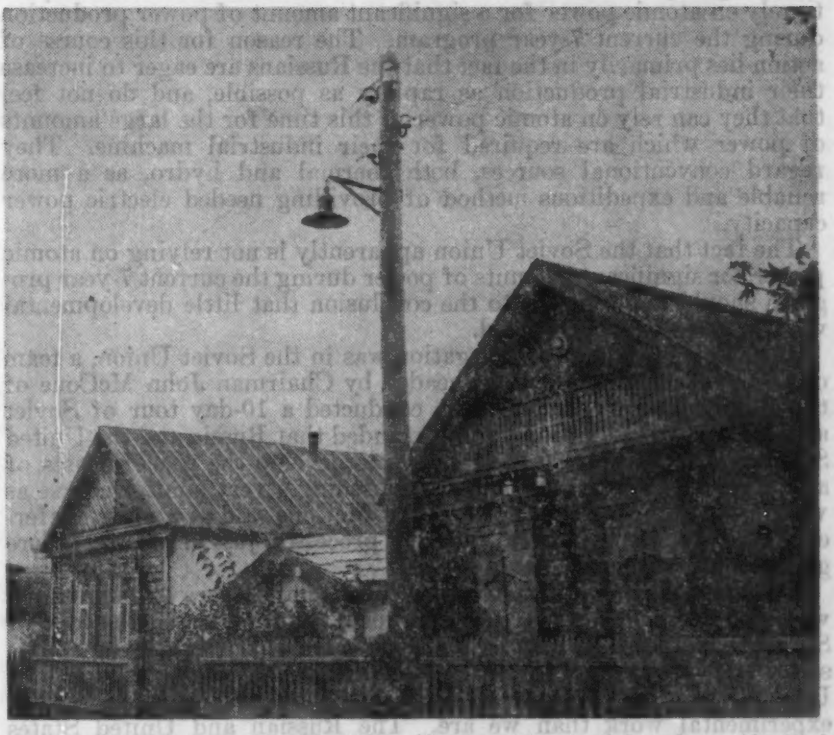
The steam pressure in these new plants, according to Mr. Novikov, will be about 170 to 200 atmospheres, temperatures will be about 580° C., and the size units to be installed will be 300,000 kilowatts.

LOCATION OF CITIES, INDUSTRIES KEYED TO DAMSITES

In connection with electric service to urban areas, an interesting sidelight is found in the Soviet Government's planning of towns and industries in conjunction with the construction of hydroelectric power facilities.

Virtually no temporary construction camps are built in the Soviet Union for the housing of workers employed in the building of hydroelectric power projects. Instead, permanent cities are built at construction sites, and as the workers complete the building of the hydroelectric projects, the housing is used to accommodate workers at new industrial plants which are built near the damsite.

This practice represents a departure from the procedure normally followed in the United States, where power-consuming industries more often are located in major population centers rather than at the damsites. Of course, the Soviet Government, by its authoritarian control, is able to place industries wherever it desires, without necessarily giving cognizance to the fact that workers may not already be located in the areas where industries are to be placed.



Russian homes—new and old style. Above, a street of brandnew identical apartments such as stretch out from most U.S.S.R. cities. These pictured are in the new city of Khrushchev, the permanent city built near Kremenchug Dam on the Dnieper River to house construction workers and their families now, factory workers later. School construction precedes apartment construction in these cities. Below are older—but also electrified—homes.

By virtue of their control over the location of industries, the Russians claim they will have no difficulty in absorbing tremendous blocks of power which are to be made available in remote locations in Siberia, where the bears seem to be the Russian equivalent of the jackrabbits that inhabited the area where Grand Coulee Dam was built.

By locating industries near hydroelectric projects, the Soviet Union also is able to utilize effectively other benefits made possible by the construction of these projects—namely, an ample water supply, low-cost water navigation, and ample recreational resources.

U.S., SOVIETS DESCRIBED AS ABOUT EQUAL IN ATOMIC POWER PROGRAM

In view of the fact that Senate Resolution 248 limited our delegation's study to water resource developments, we did not make any inquiry into the atomic power program of the Soviet Union. However, authoritative sources have indicated that the Russians will have an atomic power capacity of about 515,000 kilowatts in 1962, or possibly somewhat later.

Conversations with Russian engineers and other officials of power installations during the course of our travels within the Soviet Union led our group to the conclusion that the Soviet Union does not plan to rely on atomic power for a significant amount of power production during the current 7-year program. The reason for this course of action lies primarily in the fact that the Russians are eager to increase their industrial production as rapidly as possible, and do not feel that they can rely on atomic power at this time for the large amounts of power which are required for their industrial machine. They regard conventional sources, both thermal and hydro, as a more reliable and expeditious method of providing needed electric power capacity.

The fact that the Soviet Union apparently is not relying on atomic power for significant amounts of power during the current 7-year program should not lead one to the conclusion that little developmental work is being done in this field.

In fact, at the time our delegation was in the Soviet Union, a team of U.S. officials and scientists, headed by Chairman John McCone of the Atomic Energy Commission, conducted a 10-day tour of Soviet atomic energy installations, and concluded that Russia and the United States are about even in their efforts to develop the peaceful uses of atomic energy. The Russians are "pursuing a very similar course as we in developing nuclear power," Mr. McCone said at a press conference, and are "trying several different processes, just as we are, before going ahead with large plants."

Dr. John Williams, a member of the Atomic Energy Commission, who also was a member of the U.S. team that conducted the tour of Soviet atomic energy installations, indicated that the Russians have several large nuclear powerplants under construction, as does the United States, but are pursuing fewer new reactor concepts in their experimental work than we are. The Russian and United States scientists appear to be at about the same stage in research on how to control the H-bomb reaction to produce power—both have a long way to go, he said.

Later, in an address in Washington before the Atomic Industrial Forum, Chairman McCone said that he was especially impressed by "the speed with which the Soviets appear to be able to reach a specific objective once they decide it is of overriding importance."

He declared that—

> if we are to continue our leadership in the atomic field and, indeed, if we are to match the Soviets in other scientific areas, we must find ways to match their facility to concentrate upon and advance the important undertakings * * * we must find ways and means of consolidating our scientific and technical efforts and, when necessary, directing them on an urgent basis in pursuit of the early accomplishment of important objectives.

SOVIET AGRICULTURE AND ELECTRIC POWER

(By Clyde T. Ellis*)

INTRODUCTION

Nearly half of Russia's 210 million people are engaged in agriculture. Only a little over 10 percent of our country's 177 million are involved in agriculture.

Soviet agricultural production is not adequate for its own use. The daily diet is not well balanced. U.S. agricultural production is beyond our own needs and our daily diet is well balanced, by comparison.

Without question, the weakest link in the Russian economy is agriculture. Many recent writers have emphasized this. For instance, John Gunther in his book "Inside Russia Today" says, page 362, "Agriculture is by far the sorest spot in Russia."

Certainly it is observable that there is a general, but close, correlation throughout the world between energy expenditures, broadly defined, and wealth or well-being. So, too, we find as a corollary the existence of a close positive relationship between agricultural production per capita and the amount of energy expenditures of which electrical usage per farmworker is an integral part. Or, to say it another way, the more electricity that is used efficiently, the greater the production per farmworker.

There is also, of course, a close parallel between the amount of electricity used and the amount of nonelectrical mechanization, good soil practices, etc., for the factors that make one feasible tend to make other improvements feasible, too.

What, then is the significance of Russia's fantastic hydro and other forms of electric power production in conjunction with her simultaneous push for more and better agricultural production? She is still far behind the United States in total electrical capacity. Nevertheless, what do her giant new dams, her larger and generally more efficient generators and transmission lines—all of which dwarf anything we have in the United States—mean in terms of, let us say, not only more and better food, but also of releasing more of the population for industry and the military?

The Senate committee delegation recognized all this at the outset and made every effort to observe, gather and evaluate the facts and trends.

Therefore, some of the major problems facing Soviet agriculture are considered here briefly. Our observations and data gathered on rural electrification are included in part I. This is followed by part II, devoted to the institutions operating in Soviet agriculture which,

*With acknowledgment of valuable assistance from Dr. Tom Venables, economic officer, U.S. Embassy, Moscow, 1957–58.

while not concerned directly with electrification, give a background that shows why electrification and mechanization have not progressed as rapidly in agriculture as they have, say, in industry.

PART I

MAJOR PROBLEMS IN SOVIET AGRICULTURE

Russia is exploding. Not breaking up, but expanding its controlled economy at an explosive rate.

It is doing this by directing its resources largely into heavy industrial growth at the expense of consumer goods and services. For instance, new factories to produce giant generators, both thermal and hydro, not only for Russia, but also for China and other parts of the world, are springing up in many cities, including cities in Siberia. This, no doubt, affects rural people as much as city people.

When we visited the Kuybyshev hydrostation, largest completed hydroelectric installation in the world, and Stalingrad, which will be the largest when completed next year, and Bratsk, to be much bigger still when completed, we kept asking, among other things, "What does this mean in terms of more and better food and fiber production?"

When we asked Government officials how Russia expects to outproduce the United States in areas requiring heavy use of electricity when their total kilowatt-hour production is and will be for some time less than ours, their ready answer was, "By channeling a larger percent of our electrical production into industrial use."

Will this call for further population shifts from farm to factory? And will this in turn call for more and better rural electrification? Table 1 breaks down the Soviet manpower allocation and shows the trends since 1913.

TABLE 1.—*Employed population of the U.S.S.R. by branches of the national economy*

[In percent]

Categories	1913	1928	1937	1955	1967	1958
Total of those employed (exclusive of students and those in military service)	100	100	100	100	100	100
Including:						
Industry (small and large) and in building trades	9	8	24	31	31	31
Agriculture and forestry (inclusive of personal subsidiary farming)	75	80	56	43	43	42
Transportation and communication	2	2	5	6	6	7
Trade, public catering and supply services	9	3	4	5	5	5
Education and public health	1	2	5	9	9	10
Municipal services, cooperative, public organizations, etc	4	5	3	2	2	2
State administration, etc			3	4	4	3

Source: "The National Economy of the U.S.S.R., 1958—A Statistical Compilation," Moscow, 1959, p. 654.

NOTE.—The population living in cities is given as 48 percent; in villages including State and collective farms, 52 percent; p. 9 of above source.

The drive is on in agriculture, not to create better living conditions for the relatively backward farmers, but to press them into more mechanization, electrical, and otherwise, as a means for more and better food for the nation and to release more manpower to industry. Billboards proclaim the new goals. State and collective farm leaders say flatly they will achieve them.

Recent improvements in Soviet agriculture, observed by a group of Department of Agriculture economists who traveled in the Soviet Union in 1958, prompted them to say that agriculture today cannot any longer be considered the Achilles heel of the Soviet economy.[1] But it is still the weakest link.

Sunday farm market for animals and produce finds business brisk (and somewhat capitalistic) in rural Georgia. These items are personal property bartered, bought, and sold at the weekly market. State stores are also open for Sunday trade everywhere.

These improvements in agriculture are largely the result of reforms put into effect by Mr. Khrushchev, or "K," as he is commonly called there. He is Premier largely because, as something of an expert and longtime advocate of an improved agriculture, he was able to "prove" Stalin, Malenkov, and Bulganin failures in this area. In a short period of time he has produced much. He must produce much more.

It is true that gross production of most major agricultural products has increased rapidly in the past 5 years. But by Western standards

[1] "Economic Aspects of Soviet Agriculture," a report of a technical study group, published by the Agricultural Research Service, USDA, May 1959.

Soviet agriculture is still primitive. It has a long way to go. Production is still inefficient and relatively low. It is wasteful of manpower. Rural living conditions are not good, and the diet of both farm and city people still consists of about 70 percent cereals, potatoes, and other starchy foods.

Yet, Russia has broad expanses of agricultural land (the country is three times the size of the United States), much of it good, little eroded, flat, and therefore easy to work with machinery. Climatic conditions are generally favorable in several regions. The people have learned to live with climatic extremes in others. Russia's latitudes extend all the way from that of Santa Fe, N. Mex., to northern Canada.

What, then, does Soviet agriculture lack? The answer is that it lacks four major things: Incentives, know-how, machinery, and electricity. Electricity is listed last, not because it is the least important or the most, but because it is our assignment and is therefore treated more fully.

One could argue, of course, that Russia's agriculture also needs more fertilizer, more insecticides, better breeds and seeds and country roads, and endless other things. But these should present no serious problems under her state capitalistic system. In such a system, where the allocation of resources is in the hands of top government planners, these could be provided on short notice if and when the planners are willing to divert sufficient resources from the military, heavy industry, and other sectors of the economy.

However, such a decision could not produce, in short order, the essential incentives; the necessary farm and administrative know-how; the necessary machinery, both electric and combustion, for 105 million rural Russians; or adequate rural electrification. These have been a long time coming but a revolutionary increase in agriculture is certainly not an impossibility.

INCENTIVES

From the beginning of collectivization, which really got underway in the early 1930's, until recently the major motivation for production was supplied from above in the form of exhortation and threats. The government's system of food procurement was based primarily on delivery quotas assessed against each hectare of land. The peasant knew that he had to help his collective produce enough to meet this delivery quota and a little more or he would be faced with food and feed shortages in the period following. But he also knew that if he produced far more than the quota, the farm's quota would be promptly raised in the future, for this was the experience of those who tried to go beyond the set production norms. The individual peasant also had a feeling of futility as he looked about him and saw other collective farmers "laying down on the job" and still getting their proportionate shares of the products when the surplus was divided up at the end of the year. Therefore, the aim of each peasant was to put in the required numbers of hours—and he gave little thought to what he could produce during a given period of work.[2]

[2] Each farm task has been assigned a value, measured in "workday units," according to the skill it requires; e.g., a worker hoeing for 8 hours earned 1 workday unit, but a tractor driver in 8 hours could earn about 5 units. Thus, the worker's compensation is based on the total workday units he accumulates.

And then, the peasant just never liked the collective idea, anyway. He didn't like communism and this to him was it. He wanted more independence. So he slowed down, even sabotaged a little. Millions paid with their lives for this stubbornness.

In recent years, however, the Government has recognized that if payment to the peasant can be related to his effort, he will work harder than when this relationship does not exist. Until 2 years ago, a dual system of payment for agricultural products was in use. A very low price was paid to the farms for produce delivered under the compulsory delivery program. And a somewhat higher price was paid for produce delivered in excess of the compulsory delivery quota. But this wasn't enough.

So, in 1958, a single price system was put into practice. While the single price varies from zone to zone in the country, within a given zone a single price is paid for all produce purchased by the Government, whether within or beyond the quota. And these new prices are considerably higher than even the premium price that was formerly paid for excess deliveries. It was believed this higher price would induce peasants to produce and to sell more grain and other products than formerly. This is part of a movement to increase cash incentives to farms—part of which, in a more or less complicated way, eventually trickles down to the individual workers.

At Put' Il'icha, the collective farm we visited near Irkutsk, until this year, the farmworkers were paid a given number of rubles per day (some make more than others), and then at the end of the year they divided the surplus, after putting some in reserve. This year, however, they are paid salary only, but more salary. There is no division of the surplus. The manager thinks the plan more progressive. It's the trend among collectives, he says. But it remains to be seen whether or not in abolishing the sharing in the surplus some incentive has been lost.

The best incentive of all, apparently—and several Russians told us this—is in a "capitalistic" free-enterprise practice that is still permitted the farmers. Each is allowed a plot of his own—a little over one-half acre at Put' Il'icha. On it he can produce whatever he chooses. Naturally, he chooses fruits and vegetables for he can get more concentrated production from them. What he does not consume he may sell in the free market. Also at this collective, a farmer is allowed two cows, one hog and a litter of pigs, and all the poultry and bees he wants. His production from these, too, may be sold in the free market. And the money is all his—except for a small rent he pays the state for his stall at the market.

We visited a number of these free markets. They are in all the cities. Consistently, they offer better fruits and vegetables than do the grocery stores. Without this incentive-produced free market, the Russian diet would be in a bad way indeed.

The collective chairman-managers also have a built-in incentive. One said that if his collective produces 11 million rubles this year, his salary next year will be 1,500 rubles a month. But so far the farm has produced only 70 percent of this, so his salary is a little over 1,000 rubles a month—a little over $100 at the 10-to-1 exchange rate. Also if they exceed their goal, probably a gold medal awaits him. We did not ask him what would await him if they did not meet their annual quota increases totaling 50 percent in the 7-year plan.

There is also very little incentive for state farm workers to strive for a small increase in income. At best, the individual worker's income will only purchase the bare necessities of life. Better housing, new furniture, or other relatively high cost items are usually out of his reach; therefore, until consumer goods become more plentiful and less costly, small raises in income will not benefit him greatly. Bonuses and other fringe benefits have not played as important a part in agriculture as in industrial production. Of course, the state farmworker, too, has his little individual plot—but that is not enough.

Nevertheless, with the new drive to overtake and surpass the United States in the production of agricultural products, a start has been made with higher prices and higher salaries to increase incentives to agricultural producers. If substantial further incentive payments, too, are added, and more and better consumer goods can be purchased with the added income, then substantially increased agricultural production can be expected.

However, one acquainted with the freedoms of the Western World can only conclude, I believe, that the Russian incentives under state capitalism will still be inadequate to achieve an agricultural excellence equivalent to that of the United States. And this is said in the teeth of a U.S. trend toward corporation and contract farming, which has many of the characteristics of state and collective farming.

This is not to deprecate the possibility, however, of the Soviets borrowing enough Western incentive practices, and adding them to their own, to overcome whatever inertia now exists among Soviet agricultural workers.

KNOW-HOW

The problem of agricultural know-how exists within high government circles at least equally as much as on the farms themselves. From Khrushchev and the Minister of Agriculture, Vladimir Matskevich, on down through the government ranks, there has been an almost frantic search during the past few years for ways of improving agricultural productive efficiency. K's visit to the Bob Garst farm in Iowa was no idle lark. The Soviet Union is going through a period of trial and error; it is attempting to borrow techniques and methods used in the Western World and elsewhere in an effort to lift itself by its own bootstraps.

Since the visit of the group of Russian agriculture experts to the United States in 1955, observers have noted that some of the things they saw in this country and in Canada are being transplanted to Russian conditions. Until that visit, most of the grain crops in the Soviet Union were combined by the direct method; i.e., peasants waited until the crop was completely ripe on the stem and then did the combining in one operation.

After observing harvesting methods in the similar climate of the Dakotas and Canada, the Soviet Government instituted a two-phase program of harvesting in which windrowers are used to cut the grain a little earlier. A few days later, after the grain has dried, a combine with a pickup attachment threshes it. This permits harvesting earlier, and during inclement weather, and prevents great losses resulting from the shattering of grain left too long on the stem.

Also, after the American trip, the central government urged farmers to market their hogs at lighter weights, and encouraged the use of the two-litter production system. The milking parlor method of handling dairy cows was also observed. It is being given a limited tryout under Russian conditions.

About 4 years ago, Khrushchev decided that more corn would be the answer to increasing the production of livestock and dairy products. He insisted that every state and collective farm try corn production. (We saw matured corn in a garden some 400 miles north of the Chinese-Siberian border.) This was done despite the fact that many did not have the proper equipment for planting, cultivating, or harvesting. Furthermore, many had no background of experience in the production or handling of this new crop. As a result, much of the corn was planted by hand, hoed by hand, and harvested by hand. The net result was a reduction rather than a gain in the expected feed supplies.

In the past the machine and tractor stations had great responsibilities for overseeing agricultural operations throughout the country. They were the Government's eyes, ears, and voices locally. Most of the MTS supervisory personnel had mechanical skills, but often little training in the field of agriculture. Consequently, many mistakes were made, much effort was wasted and production was kept at low levels.

We were told that this situation, too, is being corrected rapidly since the abandonment of the MTS program and more authority has been put in the hands of dirt farmer managers and chairmen of the collective farms. For instance, Chairman Constantine Sdovnikov of Put' Il'icha (The Path Blazed by Lenin) Collective Farm near Irkutsk, Siberia, told us his collective purchased the machinery of the local MTS last year (for 1.3 million rubles—about $130,000 at the tourist rate of 10 to 1), and henceforth they will own and control their own machinery.

The agricultural institutes, too, and the various ministries of agriculture in the republics and the Soviet ministry in Moscow are all working feverishly to accumulate research data from all parts of the world which will help to bring better farm know-how to Russia. However, the big problem remains one of transferring the results of experiments and practices in other lands to the Soviet farm levels where they will actually be put into use. Khrushchev, himself, commented a year or two ago that most of the young men who are coming to the agricultural institutes for training don't know the difference between hemp and nettles. He declared that agricultural institutes should be opened in every republic as rapidly as possible, in the rural areas, not in the cities, as most of them are now.

The present know-how of Russian agricultural leaders is generally the know-how of their fathers and their grandfathers. The sudden introduction of modern techniques often throws the farm operations into confusion. Some new techniques, unsupported by others, may not help much. For example, in harvesting beets, the Soviets have developed a so-called beet-harvesting combine. It uproots the beets, passes them over a series of gratings to shake off the soil, then drops them back on the ground again where they must be picked up one by

one, topped, stacked, then picked up later, put in a cart, and hauled to the processing center. In the United States harvesting machines top, dig, clean, and elevate the beets into trucks to be hauled away, all in one simple operation. Here, unlike in grain harvests in northern climates, one operation pays big dividends.

Often, too, as new equipment is put into use, the number of men who perform the equipment operation is not reduced. For example, they still use a crew of about five or six men to operate a large combine and the wagons which collect the straw directly behind it. (They save the straw for house heating, stock bedding, etc.) Thus, the savings that might be possible by the introduction of better machinery are not always translated immediately into savings of man-hours.

There are literally dozens of ways that production could be increased and labor requirements reduced by better management and organization. Russia has only scratched the surface in applying electrical and other mechanical power to tasks done on the farm. But know-how comes with experience and, as in other fields, the Russians are trying hard and are making progress.

MACHINERY

The mechanization of Soviet agriculture began in the fields—in a big way. "Gigantomania" from the beginning resulted in the consolidation of fields into tremendous tracts for agricultural production. Large tractors, pulling large gang plows and cumbersome discs and harrows, were developed from American models and put into service. Combine harvesters also received high priority.

In 1957, 892,000 tractors were in use. On U.S. farms in the same year 4,600,000 were in use. The acreage of cropland per tractor in 1957 was 565 in the Soviet Union and only 87 in the United States. Soviet plowing, sowing, and small-grain harvesting are done almost entirely by tractor power.[3]

While the cultivation of row crops by tractor-drawn cultivators is increasing, much of this work is still done by hand. Other field operations, such as hay cutting, stacking, and hauling, and the spacing of beets, the cleaning and drying of grain, and the loading and unloading of products is done by hand or with only partially mechanized equipment. Much of the hauling between the fields and the collective villages is done inefficiently by horse or ox-drawn carts.

Despite primitive methods not yet corrected, the truck and tractor and combine might well be called the symbol of the collective farm. One sees many more trucks on the roads and highways than automobiles, and many of them belong to the collectives.

While considerable progress has been made in mechanizing the major field operations, little emphasis thus far has been put on mechanizing the village farmstead work. (Historically, Russian farmers have always lived in villages.) Many of the farm chores, such as milking, feeding of livestock, cleaning of barns, pumping water, and tending poultry are still done by hand. Most of these are done electrically in the United States, some automatically.

[3] Ibid., p. 31.

In Russia, these tasks are usually assigned to women, children, and older people. So long as there is a surplus of this kind of labor, there is little incentive for farm chairmen and managers to mechanize many of these operations. More emphasis, however, is now being placed on the production of equipment for use in the stables and around the farmyard, and we are told that many collective farms now have milking machines, feed grinders, water pumps, and occasionally other equipment operated with electric or internal combustion motors.

We are told that the situation on state farms, which has always had a higher priority with respect to procuring equipment, is much better. They are fairly well equipped electrically. We found it so on the one we visited, Digomy State Farm near Tbilisi.

The 6,000 state farms (state owned and operated farm factories)[4] work about one-third of all cropland, 129 million acres, a large part of which is in cereal crop production and is almost completely mechanized. The 69,000 collective farms (largely locally controlled) work about 356 million acres, most of which is in diverse crops, and mechanized to a lesser extent. Therefore, opportunities for further electrification of farm chores and the mechanization of field operations are far greater on collective farms than on the state farms. Opportunities for farm home electrification are also much greater on the collectives—for that's where most farm people live.

Our group estimated that the mechanization of Russian agriculture was 10 to 20 years behind that of the United States. But we agreed that, if their mechanization of agriculture should go forward as planned, the gap would be narrowed rapidly.

RURAL ELECTRIFICATION

The delegation considers rural electrification—or the lack of it—one of the four weakest links in Soviet agriculture. The task of completing the mechanization of its agricultural operations depends upon the extension of adequate electric service to not only all unserved state and collective farms, but also to all farm homes.

In America, only about half of the farmer's time is spent in the fields. The other half is devoted to farm chores, repairing machinery, marketing, etc.

Electricity makes possible many facilities which might never occur to nonfarm people. Here are just a few:

Hot and cold running water.

Automatic watering for all livestock at nonfreezing temperatures.

Indoor toilet facilities.

Electric milking and electric cooling of milk.

Pig and chicken and turkey brooding.

Supplemental heating—even house and repair shop and milking parlor heating.

Air conditioning.

Pumping for irrigation.

These mean better sanitation, too, not only for the farmers but for the nonfarmers, who also must eat the farmers' food.

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[4] For differences in the organization of state farms and collective farms, see pt. II.

Electricity adds greatly to efficiency in all these areas and releases the farmer for more time in the fields, particularly in the planting, cultivating and harvesting seasons.

Soviet statistics show that 96 percent of all state farms have electric power. Less than half of the 69,000 collective farms of the country, however, are electrified from central station sources. Another 12.6 percent have small or even mobile plants which provide light, but only a small amount of power.

But a state or collective farm may be classed as electrified without all the homes of those farms being connected. Soviet officials could not tell us the number of farm people who have electric lights or particular electric appliances. While all the farm village homes we observed on Put Ilyicha appeared to be "hooked up," it was our opinion that far less than half the rural village homes (there are few farm homes that are not in villages) along the hundreds of miles of roads we traveled have electricity. And I doubt if we saw the most backward collectives.

The very fact that Russian officials themselves don't know how many farmers don't have electric lights, electric irons, and all the other 400 electric appliances common to us in rural America, serves to point up a salient basic fact: Russia is, and always has been, concerned first about the glory of the state, secondly about the dignity and welfare of its individuals. One historian wrote of Peter the Great's travels in Europe gathering ideas to force upon his subjects: "Only one thing he did not learn, probably did not even notice, although it was the supreme advantage the West had over Russia: the Western concept of the dignity of man."[5] He could have said, "the Judeo-Christian concept of the dignity of man." Atheistic state capitalism has not changed this. Therefore, complete rural electrification by American standards may be a long time coming yet.

Soviet Government authorities do realize that the new drive to increase agricultural production and productivity of labor depends upon raising the level of electrification among the highly important collective farms of the country—particularly for their central or non-home services. State and regional planners, various agricultural institutes, and the national academy of sciences, as well as technicians on the farms, are concerning themselves with this problem and much is being written in the press and in journals about the need for expansion of this important factor in agricultural production. Particular emphasis is being placed on the need for electrifying work connected with livestock production.

On both state and collective farms, both livestock and poultry production are often carried on in giant central plants adjacent to the villages. Put' Il'icha, for instance, has 3 dairy barns that house 200 cows each and 2 housing 120 each.

Although industry will doubtless be the major beneficiary of the power development program that is going forward so rapidly, agricultural electrification can also benefit tremendously too, as more power can be spared for it, or as agriculture is given a higher priority. Table 2 shows the development of electric capacity in the Soviet Union for selected years from 1916 to 1958.

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[5] Paul Sethe, "A Short History of Russia," Gateway Editions, Inc., 1956, p. 82.

TABLE 2.—*Capacity of electric stations and production of electric energy for selected years, U.S.S.R.*

Years	All electric stations		Hydroelectric [1] stations		Percent of [2] capacity by type	
	Capacity (thousands of kw)	Production (millions of kwh)	Capacity (thousands of kw)	Production (millions of kwh)	Hydro	All other
1916	1,192	2,575	16	37	1.3	98.7
1925	1,397	2,925	26	40	1.9	98.1
1930	2,875	8,368	128	555	4.5	95.5
1935	6,923	26,288	896	3,676	12.9	87.1
1940	11,193	48,309	1,587	5,113	14.2	85.8
1945	11,124	43,257	1,525	4,841	13.7	87.3
1950	19,614	91,226	3,218	12,691	16.4	83.6
1955	37,246	170,225	5,996	23,165	16.1	83.9
1956	43,470	191,653	8,408	28,984	19.5	80.5
1957	48,397	209,688	10,040	39,429	20.7	79.3
1958	53,367	233,371	10,856	46,487	20.3	79.7

[1] Included in "All electric stations."
[2] Computed.

Source: Adapted from "The National Economy of the U.S.S.R., 1958—A Statistical Compilation," Moscow, 1959, p. 215.

The table shows that the capacity of electric stations increased steadily until 1950. From that time to the present, capacity growth has been phenomenal, reaching 233.4 billion kwh in 1958, with 46.5 billion kwh, or about 20 percent, from hydroelectric stations.

Chairman Khrushchev, in his speech to the 21st Communist Party Congress, reported in Selskoe Khozyaistvo, the Ministry of Agriculture's official newspaper, January 28, 1959, called for a big increase in the country's electric power capacity by the end of the 7-year plan in 1965. According to plan, total annual production would be increased to between 500 and 520 billion kwh—a more than doubling of production. All over Russia we saw these electricity goal figures portrayed on billboards. Khrushchev stated, however, that consumption of electric energy in industry during the same period would increase even faster, 120 percent.

He listed the following projects as principal contributors to the planned increase in electric power: Bratsk, 3,600,000 kilowatt capacity (now increased to over 4.5 million); Stalingrad, 2,530,000 kw; Krasnoyarsk, 4,200,000 kw (now designed at 6 million); Kremenchug, 625,000 kw; Bukhtarma, 525,000 kw; and Votkinsk, 1,000,000 kw. (We visited several of these.)

No hydropower program of such magnitude has ever been undertaken in the United States. In addition, many giant thermal plants will be put into service. Indeed the present percentages, 80 percent thermal and 20 percent hydro are to be maintained. In the U.S. our hydro is at present about 20 percent of our total capacity, but the administration's "no new starts" policy may reduce this percentage in the near future. Although Khrushchev did not refer specifically to rural electrification, it is apparent from various articles written since the current 7-year plan was announced that it is included, as we shall see.

The development of rural electrification between 1950 and 1958 is shown in the following table.

TABLE 3.—*Electrification of collective and state farms, U.S.S.R.*

COLLECTIVE FARMS

	1950	1953	1956	1957	1958
Total number of collective farms (thousands)	123.7	93.3	84.8	78.2	69.1
Number of electrified collective farms (at the end of year) (thousands)	18.5	20.0	28.3	30.5	32.9
Percent electrified (central station)	14.9	21.4	33.4	39.0	47.6
Percent electrified by mobile plants	.....	7.6	21.5	18.0	12.6
Percent electrified by central station and mobile generators	14.9	29.0	54.9	57.0	60.2
Utilization of electricity (millions of kilowatt-hours)	[1] 706	923	1,724	2,056	2,717

STATE FARMS

Total number of state farms	4,988	4,857	5,098	5,905	6,002
Number of electrified state farms at end of year (thousands)	3.8	4.3	4.7	5.5	5.8
Percent electrified	76	88	93	93	96
Utilization of electricity (millions of kilowatt-hours)	298	530	919	1,261	1,598

[1] Data for 1951.

Source: Adapted from "The National Economy of the U.S.S.R., 1958—A Statistical Compilation," Moscow, 1959, pp. 508 and 523.

Since less than 15 percent of the collective farms were electrified in 1950 as compared with nearly 50 percent in 1958, it is obvious that rural electrification is moving forward at a rapid pace. State farms, which have always received preferred treatment, rose from 76 percent in 1950 to 96 percent in 1958.

Rural electrification loans are made to the collectives now without interest.

As already indicated, however, there is far more to rural electrification than just extending lines to the farms or villages. The great difference that exists between rural electrification in the Soviet Union and in the United States is in the use of power once it is installed. Electricity without appliances and electrical equipment is no electricity at all. While rural electrical usage has been doubling in each country about every 5 years, Russia's has been doubling from a much lower base.

In the areas we visited (we traveled more than 12,500 miles in Russia, including about 1,000 by automobile, 360 by train, and 340 by boat), electricity apparently was used primarily for lighting and for the operation of radios. Very little was observed being used to power household and farm equipment except milking machines. Soviet rural electrification is therefore at about the same state of development, as far as power use is concerned, as it was in the United States in the mid-1930's. Still faced with the problem of extending service to half the unserved farms in the country, rural Russia must simultaneously begin the slow and expensive process of "heavying up" its lines, transformers, and other equipment to carry ever-increasing loads; and it must begin the introduction of expensive appliances and equipment to perform the various operations.

Although we had the opportunity of visiting only one collective and one state farm in detail, every opportunity was used to inquire about rural electrification.

The chairman of the electrified collective we visited near Irkutsk, Siberia, told us that dozens of electric motors were in use. We saw a few, but it was our opinion that the amount and variety of electrical

uses on the farm and in the homes fall far short of our usage in rural U.S.A. (We actually visited only one home there, a typically small one, but we asked many questions about home usage.) However, since the retail rate is only 19 kopecks—or less than 2 cents per kilowatt-hour, based on the more realistic "tourist rate" of 10 rubles to the dollar (5 cents, if the official rate of 4 rubles to the dollar is used)—to both the collective and the individual homes, we would expect sharp increases in electrical usage there as the farm strives to achieve its goal of a 50-percent increase in overall production during the current 7-year plan.

If the progress made by this farm in some of its enterprises during the past 2 years continues, it may approach the goal it has established. This farm was visited in 1957 by Senator Allen J. Ellender. The Senator's report [6] gave the number of milk cows in 1957 as 650; it had 935 in 1959. Swine increased from 1,300 to 1,700 in the same period. Similar increases were noted in poultry production and in some of the farm's other enterprises. But efficient electrification of this farm and its homes, as elsewhere in Russia, will not be achieved in the immediate future.

Finally, just before leaving Moscow to return to America, it was our pleasure to meet with Prof. Artemus Schlikhter, the leading rural electrification specialist in the Academy of Sciences, U.S.S.R., in Moscow. The Academy of Sciences serves as a sort of advisory agency to Mr. Khrushchev and in this sense is above any given ministry. The visit was at his invitation.

Professor Schlikhter and his staff are well informed on the state of rural electrification, not only in Russia, but in foreign countries, including the United States. He called our attention to the statistical data in the Soviet Statistical Yearbook, entitled "National Economy, U.S.S.R., 1958," which we have presented in the foregoing tables. And he pointed out two articles, one by himself, which have recently appeared in Soviet journals. Because these articles are extremely revealing as to the present status of rural electrification and provide some insight into the implications of the 7-year plan, and because they seem to justify the apparent urgency of complete rural electrification, excerpts from each are reproduced here, as translated by Dr. Tom Venables of the NRECA staff. [The parentheses are ours.]

"Concerning Electrification of Agriculture in the Present 7-Year Plan," by N. Karotamm, published in Questions of Economics, No. 6, June 1959:

> * * * electrification plays an important role in creating the material-technical basis for Communist society and is one of the important factors for increasing the productive strength of our country and the building of communism.
>
> Despite the great successes in mechanization and in the electrification of agriculture, much remains to be done in this field. The level of mechanization in many branches of our agriculture is unsatisfactory, especially in livestock raising. * * * Therefore, in all complex mechanization of all work in agriculture and livestock breeding, it is necessary to accelerate the tempo of electrifying agriculture.

[6] "A Review of U.S. Foreign Policy and Operations," S. Doc. 78, 85th Cong, 2d sess., U.S. Government Printing Office, Washington, 1958, p. 249.

Electrification is most important for the further raising and developing of agriculture in the present 7-year plan. It is one of the greatest factors in raising the productivity of labor and lowering the costs of production in all branches of agricultural production.

The complex mechanization of livestock raising can, and must be, carried out mainly with the help of electric energy.

In 1955, U.S. agriculture utilized 20.8 billion kilowatt-hours of electric energy (verified by FPC data).

Soviet agriculture in 1955 utilized 3 billion kilowatt-hours of electric energy, or approximately one-seventh of that used in U.S.A. In 1958, Soviet agriculture consumed not less than 6.8 billion kilowatt-hours of electrical energy. (In 1958 U.S. agriculture used 24.7 billion kilowatt-hours according to FPC data.) * * * Its use in Soviet agriculture must increase by almost four times as compared with 1958. Thus, agriculture would consume not less than 27.2 billion kilowatt-hours of electric energy in 1965. * * *.

The U.S.S.R. has all the possibilities of growth that the U.S.A. has for producing electrical energy per head of population in agriculture and per unit of agricultural land. These goals must be achieved in the shortest possible time. The role that the time factor plays in electrification is a very important consideration.

The cost of 1 kilowatt-hour of electric energy in small- and medium-sized village electric stations usually varies from 25 to 30 kopecks (2½ to 3 cents at the tourist 10 to 1 exchange rate); rarely is the cost more than 1 ruble (10 cents). However, even with such a cost, the use of electricity is economically advantageous. * * *

The author then gives data, some of which are used in the following comparative table:

TABLE 4.—*Agricultural consumption of electric energy in the Soviet Union and the United States for selected years*

[In millions of kwh.]

Year	U.S.S.R. (collective and state farms and machine tractor stations)	U.S. (all farms)	Number of times U.S. is greater than U.S.S.R.
1926	32	723	22.6
1930	49	1,789	36.5
1935	257	1,693	7.0
1940	425	3,355	7.9
1945	375	5,908	15.7
1951	1,509	15,978	10.6
1957	4,244	23,555	5.5
1958	[1] 6,800	[2] 24,737	3.6

[1] From N. Karotamm, "Concerning the Electrification of Agriculture," Questions of Economics, No. 6, 1959.

[2] Federal Power Commission estimate.

Source: Adapted from A. Schlikhter, "Several Questions Concerning the Competition Between the USSR and the USA in Agriculture," World Economic and International Affairs, September 1959.

He then continues:

> * * * in our opinion, it follows that in agriculture it is necessary to promote the construction of small and medium steam and hydroelectric stations, besides constructing large electric stations * * *.
>
> The construction of small and medium electric stations in the countryside has a highly important significance, as they will decisively resolve problems by maximizing gains in time in the worldwide economic competition our country is having with capitalistic countries. * * *
>
> Our country has all the possibilities in the next few years to build and put into operation the capacity necessary for the full electrification of agriculture. The support and initiative of the collective farmers and the state farmers and the machine tractor stations, newly organized repair stations and other enterprises of agriculture must be encouraged and supported in every way in the construction of this electrification. It is necessary to significantly develop the production of machines, equipment, and materials for the construction of small and medium agricultural electric stations. The growth of electrification of agriculture provides the possibility of quickly fulfilling the grandiose goals established by the 21st Congress of the Communist Party of the U.S.S.R. which face the agriculture of our country. * * *

Excerpts from another Soviet journal, "Several Questions Concerning the Competition Between the U.S.S.R. and the U.S.A. in Agriculture," by Prof. Artemus Schlikhter, Academy of Sciences, published in World Economics and International Affairs for September 1959 (his office, significantly, is in the Ministry of Power Building; and his secretary is the daughter-in-law of the Russian Ambassador to the U.S., Mikhail A. Menshikov):

> * * * rural electrification is an important problem in the fulfillment of the goal to overtake and surpass the United States in livestock production. Both the qualitative and quantitative development of livestock production is impractical without full mechanization and without the introduction of a complicated and versatile system of machines in all branches of livestock production, but first of all in dairying, poultry raising, and swine production.
>
> * * * with respect to the scale and tempo of raising the utilization of electricity in agriculture in the U.S.S.R. and the U.S.A., it is obvious that in absolute measure the U.S.S.R. is far behind the U.S.A. However, its tempo of development significantly approaches that in the U.S.A. * * *.
>
> The 7-year plan must introduce significant changes in this sector of the competition. * * * We must find ways to put our collective farms and state farms on the level of consumption approximating 25 billion kilowatt-hours. In American literature it is assumed that the use of electricity in American agriculture, by 1965, will be at a level approximating 40 to 50 billion kilowatt-hours. * * *

It should be noted that in the United States agriculture consumes a larger share of the country's electric production than in the Soviet Union. In 1930, Soviet agriculture used 0.6 percent of the total; in the U.S.A. agriculture used 1.4 percent of the total. In 1951, the comparison was 1.5 and 3.7 percent. In 1957, 2 and 3.2 percent. In 1965, the share of Soviet agriculture will stand at approximately 4.6 percent which will be higher than the U.S. figure. * * *

In 1958, only 3.6 percent of the collective farms milked cows mechanically. * * * In 1940, 43 percent of U.S. farms had pressure water systems, and, in 1956, two-thirds of all farms had such water supplies. In 1958, only 20 percent of the cattle-raising enterprises of Soviet collective farms had water piped into the livestock barns.

In 1957, practically all farms in the United States were electrified. In 1957, all machine tractor stations and almost all state farms in the U.S.S.R. were electrified, but only 39 percent of collective farms had electricity. (In the U.S.A. 38.3 percent of all farms were electrified in 1942.) (Many small, inefficient and no doubt many unelectrified collective farms were consolidated into large collectives in 1957 and 1958. This accounts in part for the sharp rise in the number of electrified collective farms between 1957 and 1958.)

The 7-year plan creates the necessary conditions for electrifying all collective farms in the country and for thoroughly applying electric energy to the mechanization of all processes in agricultural production.

The fulfillment of the 7-year plan provides for enormous increases in the production of agricultural products and, above all, in the production of livestock; it makes rural electrification and the outstripping of the U.S. in this sphere one of the major problems of the building of Soviet agriculture. * * *

We really should not forget, also, that in the electrification of agriculture it is not only the electrification of production (that is important) but there is also involved more thorough electrification in the homes. In this is included one of the important material conditions for erasing the important differences in living conditions, of life and culture between the city and the village. * * *

It is clear from the first article quoted that rural electrification in the Soviet Union is sadly underdeveloped. Even the recommendations for the establishment of small village generators can be viewed in the long run as only a temporary solution to the problem. For as electrical uses develop and mechanization increases these small plants will be unable to cope with the growing demand for power and the cost will be high.

These recommendations are typical of the haphazard methods that are frequently used in the Soviet Union, just for the purpose of fulfilling grandiose plans laid down by the central authority. The problem will not be solved until transmission and distribution lines are constructed which will tie the villages to central power supplies.

While this is not stressed in these articles, we learned that it is being done at a rapid pace. Digomy, the grape-growing state farm in Georgia, is connected to the Georgian transmission grid and Put Ilytch is already tied to the Siberian grid. The achievement of this goal should be easier in the Soviet Union than it has been in the United States since state farm workers and the collective peasants do not live out on the land they till but are concentrated in small centralized communities.

It is interesting to note that the planners, such as Professor Schlikhter, are beginning to think of electricity in terms that go beyond its uses for merely increasing production. This could be significant in moving state capitalism more in the direction of individual capitalism.

SUMMARY AND CONCLUSIONS OF PART I

In summary, Mr. "K" has boasted to his own people and to the world that he will equal and surpass the United States agriculturally. He is on the spot. He must produce—and somehow he will—or else.

He has the land, the climate, the farm people. He does not have the incentives, the know-how, the farm machinery, or the rural electrification.

He can produce the machinery—even for more thorough farm mechanization than we enjoy, by simply directing some of his exploding economy into that channel. He can acquire the know-how, but he cannot adapt and filter it down to 100 million farmers at sputnik speed. He can improve the incentives, but under state capitalism he may have difficulty equaling American farm free enterprise incentives. He can equal or surpass in short order our rural electrification generation, transmission and distribution system, but he will have to change a lot of things, including farm income and farm housing, before he can equal us in the supply and usage of farm and home equipment and appliances.

However, we may be exhibiting a degree of complacency which is not warranted. The Soviets, in essence, are attempting to do in their own way what all modern industrialized nations have had to do in order to achieve a high degree of industrialization.

To accomplish this, of course, agriculture must be made vastly more efficient so that resources—human and otherwise—can be channeled into other endeavors. But the Soviets, like all "late comers on the scene" may have a decided advantage. By being able to borrow the best available technological know-how, without the usual inhibiting institutional fetters—and this runs the whole gamut of know-how, incentives included—and by directing such "unfettered" technology through less restrictive patterns of behavior or political or social institutional frames of reference the "impossible" may be achieved—and sooner than we think.

If and as all this is done, 90 million Russians can be released from the farms to the military and to industry and other segments of the economy. No doubt much of it, but not all, will be done—and swiftly. That old crack, "the moon is the limit," meaning the impossible, no longer applies to the Soviet Union.

Part II, which follows, provides background for a better understanding of part I, and of living and working conditions and other problems in Soviet agriculture.

PART II

Factors Affecting Soviet Agricultural Progress

INTRODUCTION

A country's agriculture is the product of its natural and human resources as influenced by public policies and the customs and historical background of its people. But also as important if not more so is the ability, perhaps especially so as regards the Soviet economy, of the Soviets to redirect or reorient cultural patterns of behavior over a period of time to fit in with an ever-increasing technological base upon which to build their national economy.

Although brief, the following sections—based on firsthand observations, on conversations with people from many levels of Soviet society, and on published information—describe the major factors which have influenced Russian agriculture in the past, and which will bear upon its future course. And since about half the Russian people are "bound to the land," as noted in part I—whereas only 10 percent are bound to the land in the United States—the course of Soviet agriculture is almost certain to materially influence the future of the world. If Soviet agriculture can be raised to the level of U.S. efficiency, as Khrushchev says it will be, then 67 million people, based on the present population, could be released from the land to the military, to industry and to other sectors of the economy.

LATITUDE

The longstanding impression that Russia lies far to the north, has severe winters and short growing seasons cannot be denied. However, as in our own country, there are wide variations. Table 5 shows the latitude of certain cities and areas, with comparable locations in North America. We visited all these Russian cities, but did not get into Soviet south-central Asia.

Table 5.—*Approximate latitudes of Russian cities and areas compared with selected locations in North America*

Russian cities or areas	*Comparable area in North America*
Irkutsk	Lower part of Hudson Bay.
Kharkov (in the Ukraine)	Winnepeg, Canada.
Leningrad	Northern Hudson Bay.
Moscow	Southern Hudson Bay.
Rostov-on-Don	Bismark, N. Dak.
Stalingrad	Grand Forks, N. Dak.
Tbilisi	Des Moines, Iowa.
The most southern part of Soviet central Asia.	Santa Fe, N. Mex.
The Crimea	Minneapolis, Minn.

Most of the Soviet Union lies north of continental United States, except Alaska. Certain natural features, including bodies of water, tend to temper the climate in the southwestern regions. Most areas, however, are subjected to the most severe climatic conditions for there are no mountain ranges to resist the flow of arctic air or the hot, dry winds which flow westward off the deserts.

PRECIPITATION AND GROWING SEASON

Besides the severe winters and the short average frost-free summers, annual precipitation in the important agricultural regions is not ample, although often well distributed. We were told in the Don and Volga Valleys and in the Ukraine that the limited rainfall is usually so well distributed that irrigation would not pay. However, some of us were not convinced. Table 6 shows the number of frost-free days each year and the annual precipitation for various localities.

TABLE 6.—*Growing season and precipitation for selected cities in the U.S.S.R.*

Station	Average frost-free period in days	Precipitation (annual average) in inches
Irkutsk	95	15.5
Kharkov	151	20.2
Kiev	172	23.2
Krasnodar	190	25.6
Leningrad	160	20.6
Moscow	130	24.4
Stalingrad	177	14.6
Tashkent, in central Asia	206	13.7

Source: Adapted from Agricultural Monograph No. 5, p. 6. (See footnote 7.)

The relatively short frost-free period and the low average rainfall are serious handicaps to agricultural production and to further agricultural expansion. The short growing season is accompanied by relatively cool summer temperatures, greatly limiting the crops that may be grown in the northern and central regions. Also, in most of the areas of abundant rainfall, both the soil type and the growing season are less favorable.

The best black soil zones of the Ukraine and of the Kuban regions in the north Caucasus rarely receive more than 25 inches of moisture, often less. Thus the Ukraine, traditional Soviet breadbasket, operates on a climatic margin similar to that of our northern Great Plains. The new lands, brought under cultivation in Kazakhstan and southern Siberia during the past 5 years range from 10 to 16 inches in precipitation. This is too little for abundant crops and pastures.

LAND AREA, CLIMATE, AND SOILS

In approaching the problem of natural environment, a statement made by Dr. Lazar Volin of the U.S. Department of Agriculture, the leading U.S. authority on Soviet agriculture, is appropriate:

> It is axiomatic that agriculture must adapt itself to its natural environment—the soil and climatic conditions—which can be changed only to a limited extent by man, and then only at a cost. At the outset, however, one must guard against exaggerated notions about the natural resources of Russian agriculture, which are often depicted in colors either too optimistic or too pessimistic.[7]

[7] Volin, Lazar, "A Survey of Soviet Russian Agriculture," Agricultural Monograph No. 5, USDA, p. 1.

In spite of the fact that the total area of the Soviet Union represents about one-sixth of the earth's surface—three times the size of the United States—only slightly more than 10 percent of its total area is now classified as tillable. If one adds the permanent meadows and pastures, much of which could be converted into cropland, about 25 percent might be tillable. On the other hand, more than 20 percent of the land area of the United States is tillable and if to this is added meadows and pastures the percentage rises to nearly 60 percent.[8] In spite of a lower percentage of tillable land the Soviet Union has a much larger acreage under cultivation than the United States (U.S.S.R., 576 million acres of plowland, 1955; U.S.A., 399 million acres of plowland, 1954.)

Students of Soviet agriculture have long delineated what they call the "fertile triangle," an area in which the best agricultural prospects exist. This is formed by drawing a line from Leningrad in the northwest 2,770 miles east to Irkutsk in Siberia, back 3,200 miles to Odessa in the southwest and then north 925 miles to Leningrad. While the best soils and most favorable climatic conditions generally exist in the triangle, this is not to say that agriculture cannot be, and has not been, pushed north and south and east and west of these boundaries, and perhaps may even go farther with additional technological innovation and know-how including, for example, extensive use of irrigation which would, of course, have to be predicated upon substantial increase in the generation of electric energy.

The best black soils prevail in the Ukraine and the north Caucasus areas—in this triangle. As one goes farther east of these regions, this band of most fertile soil narrows and finally almost dwindles away near Irkutsk. A small pocket of such soils also lies still further to the east. For some distance north and south of this zone, the soils shade off, gradually becoming less productive.

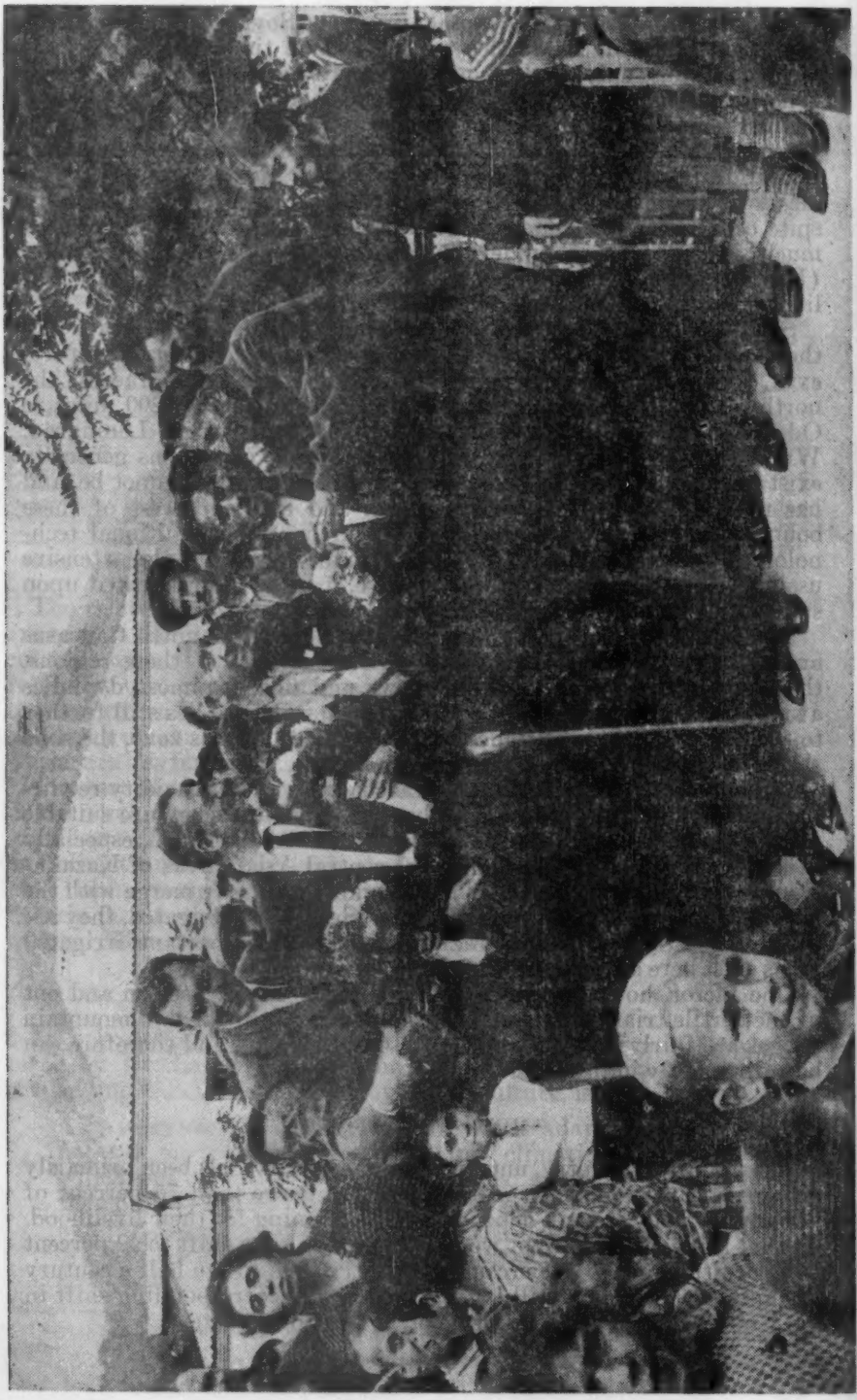
To the north in the old forest areas are soils of high acidity requiring lime and fertilizers to make them productive. They are suitable mostly for grazing, hay and small grains. To the south, especially in the lower Volga region and in the central Asian areas of Kazakhstan, the soils become degraded black lands and finally merge with the sandy desert directly east of the Caspian Sea. If unirrigated, they are suitable mostly for sheep grazing. However, important irrigated areas exist here as well as in the trans-Caucasian republics.

One factor, however, is greatly in Russia's favor, both in and out of the fertile triangle: most of her lands outside of the two mountain ranges are fairly flat, not subject to severe erosion, and therefore can be permanently improved.

HUMAN RESOURCES

As in our own country, until recent years, Russia has been primarily an agricultural economy. As late as 1913, more than 75 percent of her population were still dependent upon farming for their livelihood. At that time only 9 percent were in industry. The shift to 42 percent in agriculture and to 31 percent in industry in less than half a century is significant even if it still lags far behind the corresponding shift in the United States. (See table 1, pt. I, for Soviet data.)

[8] Ibid.



All over the U.S.S.R. workers as well as officials were cordial to the U.S. observers. On the opposite page, Georgians receive Senators Muskie, Moss, and Gruening with flowers and questions.

At the upper left of this page Senator Moss and a senior citizen gaze over the great reservoir of Asia—Lake Baikal. At the upper right a Georgian schoolboy is fascinated to behold his first American. At the lower left a Siberian man and wife stand outside their collective farmhouse into which they welcomed visitors. At the lower right a Ukrainian construction girl stops building Kremenchug Dam long enough to bestow a smile.

One of the Soviet Government's major problems over the past 40 years has been the reallocation of human resources according to the priorities of economic development established by the central authorities. While achieving some success with such manpower assignments, especially for industry and the military machine, the process has not been carried out smoothly. It was only natural that the peasantry should be looked upon as a great manpower pool to supply workers for the country's expanding activities. However, a disturbing imbalance of manpower resulted from internal revolution and its aftermath and from World War I and World War II. A large segment of the country's able-bodied men died in these holocausts, and the gap is still there.

In 1930, and in the years following, Government policy dictated the liquidation of the kulak class in agriculture. The kulaks, the relatively well-to-do landowners, were for the most part the managerial group who knew most about the operation and management of farmlands. Their liquidation along with that of all the nobility left a great void in agriculture which the remaining uneducated peasants were unable to fill for many years. Therefore, farming, long neglected as to machinery, equipment, and know-how, had to depend on great masses of unskilled men and women using largely slow and cumbersome hand methods.

And the peasants took to communism little better than the kulaks. Immediately after the nationalization of all lands in 1920, peasant resistance brought agriculture to a near standstill. In the mid-twenties a new economic policy (NEP) introduced by Lenin eased the situation somewhat.

But in the late twenties Soviet agricultural policy took a still more drastic turn. Its objective was to liquidate feudal peasant agriculture and develop large-scale, socialistic-type farming. The Bolsheviks believed that large-scale production methods would work as well in agriculture as in industry. Anyway, it would help to humble and control the stubborn peasants.

It did, but millions of them died, too.

The Government was determined, at all costs, to obtain the largest possible supply of grain and other agricultural products—at low prices—for its new state industries, for its rapidly increasing industrial workers and for export. And the Government prevailed.

With the emphasis on developing industry the Soviets then further drained off particularly the men from the already depleted rural manpower at a rapid rate. For as a result of the revolution and other wars, the whole Soviet Union had, and still has, a shortage of not only manpower, but of men, and up until now, science and industry had to come first.

It is not surprising, then, that a great many women still are engaged in agricultural work—we saw them everywhere in the fields—and that many have gone into industry, commerce, and the professions.

Today, about 60 percent of the manpower in agriculture consists of women [9]—women performing largely the menial tasks in the fields and in livestock and dairy production. And elsewhere in the economy, women work side by side with men, not only in the factories but at

[9] See note after table 7, p. 118.

heavy construction work as well. Surely nearly half the highway construction and maintenance workers we observed along hundreds of miles of roads in many parts of Russia were women. We were told there is a tendency toward fewer women working at hard labor, and this trend, though moving slowly, is borne out by Soviet statistics. Table 7 shows the distribution of women in industry and in other occupations.

TABLE 7.—*The percent of women to total employed in various occupations in the U.S.S.R. for selected years*

[In percentages]

Categories	1929	1940	1955	1957	1958
Total for the nation	27	38	45	46	46
Including:					
Industry	28	41	45	45	45
Building trades	7	23	31	31	30
Agriculture (exclusive of collective farms)	28	26	24	25	20
Including:					
Machine tractor stations		11	9	7	7
State farms and auxiliary enterprises	28	34	46	43	40
Transportation	9	21	29	28	28
Communication	28	48	60	61	62
Trade, public, catering, procurements, material technical supply	19	44	64	65	66
Of which, public catering	46	67	83	84	84
Public health	65	76	85	85	85
Education	54	58	69	69	69
Science and scientific service	54	58	41	40	41
Credit and insurance establishments		41	63	64	65
State and economic administration, cooperatives and social organizations		34	47	48	49

Source: Adapted from "The National Economy of the U.S.S.R.," 1958, p. 664.

NOTE.—The USDA delegation of economists to the U.S.S.R. in 1958 was told that about 60 percent of the workers in agriculture were women.

In 1958, despite the recruitment of men and women from agriculture, 52 percent of the population lived on farms and in rural settlements, and only 48 percent lived in cities. Only 12 percent of the American population lived on farms in 1958.

Whereas Soviet authorities made a conscious effort to quickly transfer manpower from the country to occupations in the city, greater shifts occurred in the United States in the same period as a result of economic forces rather than political decisions.

While we saw no evidence of unemployment in agriculture, we did see evidence of underemployment, because of many primitive methods used.

AGRICULTURAL INSTITUTIONS

Before the revolution, Russian agriculture consisted of a relatively small number of large landlord holdings and millions of small peasant holdings. One of the aims of the Bolsheviks was to break up all these holdings and reestablish them in large and more economic units under state control.

Until 1957, Soviet agriculture rested on three main pillars: the collective farm (kolkhoz), the state farm (sovkhoz), and the MTS (machine tractor station) to service the collective. Since 1957, the machine tractor stations are being eliminated. Their machinery and equipment are being sold to the collectives.

COLLECTIVE FARMS (KOLKHOZY)

Title to all land now belongs to the state, of course. The collectives comprise 74 percent of all farmlands. A collective farm, usually the area around one or more rural villages, is made up of all the land formerly owned by the landlords and peasants. It is mostly organized into large fields for use of heavy field equipment. Also, each family is allocated a small plot as its own, the amount ranging from about one-half acre to 2 acres. This he may use as a family garden or to produce feed for a limited amount of livestock that he may own and keep for his family use.

While some semblance of democracy is apparent in the farm's organization, notably in the selection of management personnel, it is operated within a pattern prescribed and rigidly controlled by the Government. Thus it forms an integral part of the Soviet planned economy. Membership in the collective is made up of the families living in the villages.

By a complicated system of bookkeeping, the workday units earned by each member are carefully tabulated day by day. A worker may earn from one to several workday units in a day, depending on what he does.

At the end of the year part of the crop is delivered to the state food procurement system. Part of the feed and seed is retained on the farm for the coming year. Some products are converted to cash and put into various reserve funds of the collective. The residual is—or was until recently—divided among the peasant members. Some collectives are abandoning the division of residual surplus and paying higher salaries instead. Put Ilyicha collective, which we visited near Irkutsk, Siberia, has changed over to higher salaries with no division of surplus.

The usual workday on a collective farm is 8 hours. The peasant and his family may work on their private plots when they are not busy in the communal fields. The peasant in this way can increase his personal income by forcing production on the limited area he calls his own. It is quite apparent as one travels through the country that the care given to the small private plots is better than that given to the large communal fields with their large communal equipment.

STATE FARMS (SOVKHOZY)

One of the first acts of the Bolshevik government was to appropriate for the state the large estates held by noblemen and other large landowners. Often these large estates had well-developed enterprises, producing beef cattle, dairy cattle, horses, sheep, wheat, cotton, sugar beets, or some other crop. Rather than break up these large land areas among peasants, the state retained them for its use and established them as state farms on which employees are paid wages just as other factory workers.

In time, other state farms were organized from land formerly held by small peasant operators. State farms often are regarded as state experiment stations, but even though experimentation in crop and livestock production is carried on, the primary purpose of the farm is to produce food and fiber for the nonfarming population.

Table 8 shows the steady rise in the number of state farms, partly at the expense of the collectives. Whereas collectives were organized rapidly before World War II, their number has since decreased steadily as a series of decrees has consolidated many into larger units. Note the growing number of households per collective farm.

TABLE 8.—*State farms, machine tractor stations, and collective farms, U.S.S.R., for selected years*

Category	1928	1932	1940	1950	1957	1958
State farms	1,407.0	4,337.0	4,159.0	4,988.0	5,905.0	6,002.0
Machine tractor stations	6.0	2,446.0	7,069.0	8,414.0	7,903.0	345.0
Collective farms (in thousands)	33.3	211.7	235.9	123.7	78.2	69.1
Number of households in collective farms (in millions)	.4	14.7	18.7	20.5	18.9	18.8
Average number of housebolds per collective farm	13.0	71.0	81.0	165.0	245.0	276.0

Source: Adapted from "The National Economy of the U.S.S.R.," 1958, p. 349.

The state farm we visited in Georgia is a "grape factory." One we saw in the Volga Valley is called a "chicken factory." With its hundreds of buldings extending over a vast area, it resembles a factory more than a farm.

State farms have always had the best the state could offer in the way of buildings, equipment, electrification, fertilizer, and all of the other requisites of living and production.

EXTENSION SERVICE

There is no extension service in the Soviet Union comparable with that of the United States.

Innovations in agriculture are put into practice on farms under the supervision of agronomists, animal husbandry specialists, and other specialists on the staff of each collective and state farm.

These specialists are trained in various agricultural colleges and experiment stations throughout the country. They are kept up to date on Government policy and new technology by direct contact with the various Republic Ministries of Agriculture (15 in all) and by the central Ministry of Agriculture in Moscow, all of which have well educated and trained specialists in many fields. Decrees and orders play an important role. Adult education seminars are conducted on each farm as new techniques are being introduced.

MARKETING FARM PRODUCTS

Agricultural products come to market by a system of state procurements and by voluntary deliveries from the farms and individual peasants.

Historically, collective farms and peasants had fixed compulsory delivery quotas for most products which the state purchased at low prices. Deliveries made in excess of the quota were purchased at somewhat higher prices, for incentive purposes.

In 1958 delivery quotas were removed from the small individual plots. Later in the same year the term "compulsory deliveries" was

dropped and each collective, with guidance from higher authority, worked out planned procurement estimates to determine the minimum quantity of produce to sell to the state. Since 1958 the state pays higher prices than formerly for all purchases. These prices were set higher to induce farms to sell to the state more than the planned estimate. Collective farm income, however, is still pitifully low. And so is that of the peasants on the collectives.

State farms deliver to state collecting points all they produce except the amounts needed as food, feed, and seed on the farm.

State farmworkers also have individual plots and may consume or sell livestock and produce raised on them. They may sell to the state at "procurement" prices, or they may sell in the free market for the best price they can get.

There are two major outlets for farm products:

State stores.—Most produce is retailed through what are known as state stores. The state operates shops for dairy products, fruits, and vegetables, cereal products, fowl, fish (lots of it) meats, and other food. Prices on these necessities normally are lower than those of the free market. No one seems to care whether state grocery store products are sold or not. Consequently the state stores are seldom attractive by American standards.

Free market.—The free market usually is an area in which permanent stalls have been established by the city or town for displaying and selling farm products. Part of it is usually covered for rainy and winter weather. Collective farms and individual peasants bring goods and produce here. They pay for the space, scales, and sometimes other services to cover overhead costs of the market management. Prices they ask are determined largely by supply and demand conditions. They thus have an incentive to produce high quality foods and display them attractively. Consequently, the products are better and better accepted than those found in the state stores. Housewives usually prefer to buy in the "free market"—and rely on it.

We visited several collective (free) farm markets, and it was most refreshing to see that there are still vestiges of freedom and competition, if only in a limited sector of this highly organized and controlled state system—vestiges that outshine their communal counterparts.

RECENT CHANGES IN SOVIET AGRICULTURE

Until at least very recently, unrest has continued to smolder among Soviet peasants since the days of forced collectivization and the purges. Many remember well the hardship, privation, and even death that came to their families unnecessarily during the early and middle stages of Soviet development. Peasants have always resented the loss of title to their land and the forced state collection of produce. Sometimes they cheated the Government; sometimes they sabotaged the state's programs. We have heard that a feeling still exists that the state is something apart from them and that this has made them careless of state equipment and wasteful of the state's share of the products they raise. However, we saw no evidence of this.

For years force, rather than incentives, drove the peasants to produce what they did for the state—which often was not much. Therefore, in Stalin's time, much abuse was heaped on the heads of the

peasants and on the administrators who supervised agriculture. Yet Stalin himself rarely bothered to go into the country to observe the peasants' situation.

As Khrushchev gradually gained control, he sought the support of all groups, but especially he sought the support of the largest group of all—the unpredictable peasants. Perhaps partly for the selfish motives of greater power and partly because he appreciated the need for spurring the peasants to greater productive efforts, he soon instituted a number of reforms and innovations.

His most dramatic action was the announcement that the pressing food problem would be solved by the opening up of long-idle and virgin lands in eastern areas, including southern Siberia, and Kazakhstan. Between 1954 and 1958 more than 90 million acres, an area larger than the wheat acreage of Canada and the United States combined, was brought under cultivation in the so-called "new lands" region. Despite the climatic hazards, fairly good wheat yields were harvested in 1954, 1956, and in 1958. Although a gamble, this land, mostly in state farms, has provided the country large additional quantities of grain. It remains to be seen whether production can be maintained at these levels.

As a corollary to the new lands program, Khrushchev advocated, then gave force and effect to a program calling for sharp increases in livestock and all types of livestock products. Much land in the European part of the U.S.S.R., formerly used for wheat, was to be shifted to feed crops. To date, livestock has increased considerably, but the milk, meat, and butter goals appear to be higher than the country can achieve in the near future. The livestock program needs much greater emphasis on electrification and mechanization if production efficiencies are to be realized.

As already noted, "K" sold the machine tractor stations to the collectives—but only after giving the people a chance to write the Government and press about his plan to do so.

Khrushchev also sent his agronomists and economists scurrying into the countryside to make soil and climatic studies in every region so that crop production could be based on the land capabilities.

Other reforms, already mentioned, were carried out, too, including the lifting of compulsory delivery quotas on products grown by peasants on their privately held plots, the raising of procurement prices, and simplification of the state procurement system.

COMPETITION WITH THE U.S.A.

For several years, the rallying cry in the U.S.S.R. has been for agriculture and industry to catch up with and surpass production in the United States. The press and billboards are full of comparisons between Soviet production and that of the United States. Always they show the rate of U.S.S.R. production exceeding the growth rate of the U.S.A. Every factory and every farm has posters and charts exhorting the people to catch up with the U.S.A. This competition has become an obsession with the Soviet people. They speak of it at all times. They show it in the pace of their work—even in the pace of their walk. No wonder they respect us, despite all the uncomplimentary propaganda.

In agriculture it appears likely that gross production of many products may reach the levels attained in the United States, but it appears unlikely that overall production per capita will achieve our level for a long, long time.

But production is not all. One must look at the cultural situation of the Soviet people. There is little new rural housing under construction and most of their homes are probably not over half as large as average rural American homes. And far more primitive.

Life is hard, drab, and unrewarding in rural Russia. There seem to be no luxuries. Labor is kept hard and inefficient by lack of modern equipment on all but a few major crop operations.

Many said to us something like this:

> We know your standard of living is higher than ours, but things are better this year with us than last year, better than 5 years ago, or before the revolution. We are gaining and we will catch up with you.

Possibly they will, if given enough time, but that time is a long way off unless some Russian near-miracle can be achieved in this area, too.

SUMMARY AND GENERAL CONCLUSIONS

Russia's agricultural disadvantages lie in the fact of her extreme northern latitude and low rainfall; her historic backwardness and resultant lack of present day know-how; her lack of men in proportion to the number of women; her lack of machinery, lack of rural electrification, and lack of incentives.

Her advantages and agricultural potential lie in the fact of her vast land mass—three times that of the United States—extending into 12 of the earth's 24 time zones; her proximity to almost unlimited agricultural market demands; her percentage of plains-type terrain well adapted to machine plowing, seeding, cultivating, and harvesting; her manpower reserve as more machinery is introduced; the relative ease with which her farms can be electrified since the farmers live in villages adjacent to their large barns, greenhouses, etc.; and, perhaps most important of all, the fact that as a result of already determined Government decrees apparently a crash program is in the making to produce and allocate the necessary electricity, machinery, and fertilizer.

How the Soviets can gain and disseminate among her 88 million farmers, or even among the leaders, the necessary know-how, and how they can create the necessary incentives to outdo the United States agriculturally by 1965 or any other foreseeable date, except possibly in small grains production, is beyond our comprehension. But so are her sputnik successes beyond our comprehension.

Has a decision already been made which would release 60 million Russian people from the land to the military and to industry by rapidly "Americanizing" her agricultural methods? We don't know. But we do know what Khrushchev is promising and boasting.

The fact is that things are being done to increase Russian farmers' incentives; know-how is increasing; the production of fertilizers, insecticides, and the like are being increased; and farm mechanization and electrification, among the factors that can produce the most rapid

improvement, appear to have the aggressive suport of Mr. "K" and his planners.

The peculiar Soviet type of political economy involving both unique forms of political and economic institutions is apparent. Also observable is the Soviet's fantastic pace at which knowledge and technology are being accumulated, especially in fields other than agriculture. These factors, coupled with the ability to more rapidly overcome cultural inhibiting factors, may well increase the rapidity with which the Soviet Union is able to achieve efficiencies in agriculture. Western culture may indeed marvel at the pace.

But perhaps more important, the accomplishments of the Soviets in this as in other respects may have a greater bearing and influence on other less developed nations seeking to industrialize, e.g., China.

The only safe course is for U.S. citizens to improve our pride in our own agricultural complex, by far the world's best and still our largest industry; improve our appreciation even of our agricultural surplus, which someday may vanish almost overnight, and help increase our agricultural efficiency wherever possible—including continued improvement of its rural electrification.

ORGANIZATION FOR ELECTRIC POWER SUPPLY IN THE SOVIET UNION

(By M. C. Mapes, Jr.)

Reason and justice tell me that there is more humanity in electricity and steam than in chastity and vegetarianism.—ANTON PAVLOVICH CHEKHOV.

Communism is Soviet political power plus electrification of the entire country.—NIKOLAI LENIN.

The two quotations above seem to summarize the Soviet view of electric power which we encountered repeatedly during our trip—that it is an essential humanitarian tool necessary to make possible an improved standard of living for all people, and it is the key material basis for the establishment of Communist power. How the Russians have organized the industry which they consider so critical to the service of the Soviet concept of humanity and to the furtherance of the cause of communism will be summarized in this report.

All major facilities for the generation and transmission of electric power in the Soviet Union are government-owned and operated; since these facilities constitute the second largest national power development in the world and the only one which shows any possibility of challenging U.S. supremacy in this field within the foreseeable future—and since they belong to the nation whose leaders have stated their intention to surpass the United States in a worldwide economic competition—they obviously compose an industry of major interest to this country.

Until January 1959, the electric power industry in the Soviet Union was planned, constructed, and operated almost entirely under the direction of the Ministry of Electric Power Stations. In that month, at the very commencement of the new 7-year plan, the Ministry of Electric Power Stations was abolished and its functions split up in a reorganization which, among other effects, resulted in a substantial redistribution of both authority and responsibility. While the newly created Ministry of Electric Power Station Construction was invested with slightly more extensive responsibilities in the field of station construction, it was relieved of several functions formerly vested in the Ministry of Electric Power Stations, such as national planning and overall control of electric power production, which are now split between the All Union Council of Ministers (similar to the President's Cabinet in the United States) and the Councils of Ministers of the 15 republics of the Soviet Union. In like manner the regional electric power stations and grid systems, which were part of the Power Ministry system prior to the industrial reorganization of 1957, have now been placed under control of the "sovnarkhozes," or regional economic councils, for operation and maintenance.

The reasons for this rather fundamental reshuffling of the Soviet power industry have never been completely explained, but it obviously resulted from dissatisfaction with the status quo on several levels of government. Minister of Electric Power Stations Pavlenko was replaced in the new Ministry by his 53-year-old former Deputy Minister, Ignaty T. Novikov, who impressed our delegation as a competent engineer and able administrator, as well as our courteous host. On February 2, 1959, shortly after taking his present position, Mr. Novikov explained the reorganization and the functions of the new Ministry in a public address in the following terms:

> Comrades, recently a specialized all-union Ministry for Electric Power Plant Construction was set up by our party's Central Committee and the government, a ministry which is entrusted with insuring the construction of power supply in the U.S.S.R. The urgency of such a decision is confirmed by the fact that several councils of ministers of union republics, party organizations, and many sovnarkhozes have themselves introduced suggestions also calling for the transfer to the new ministry of building organizations and plants linked with power supply construction.
>
> The aim of these measures is to insure the complex [complete(?)] outfitting of electric powerplants and powerline systems, since thus far many sovnarkhozes have merely done the construction work for outfitting electric powerplants and the former Ministry of Electric Power Plants only the outfitting work and the assembling of the equipment. The U.S.S.R. Ministry for Construction of Electric Power Plants will carry out the building of all major electric powerplants, high-voltage powerline systems and substations, the assembly of powerplant equipment, and the surveying and planning of powerplant enterprises.

Unspoken by Minister Novikov, but probably very real in the eyes of the "several councils of ministers of union republics" and "many sovnarkhozes" referred to, is the fact that if local organizations are to be charged with responsibility for the production levels of local industry it is only reasonable for them to want control over production and distribution of the electric energy on which that production is so largely dependent. This they have obtained under the reorganization, and to this extent it constitutes a major decentralization of authority—a shift of economic power from Moscow to the farflung economic regions of the country. In answer to inquiries as to the reasons for the change, we were informed that the primary purposes of it were to unify the construction work on electric plants and systems and to decentralize and localize their operation, a response which seems to support the above interpretation.

THE MINISTRY OF ELECTRIC POWER STATION CONSTRUCTION

Our Soviet hosts were quite willing to discuss many aspects of their operations, including the organization of the Ministry itself. In reply to a series of written questions submitted by Senator Moss we were supplied with an organization chart of the Ministry and a summary statement of some of the functions performed by its various branches.

A translated copy of the chart is attached as part of this report, and rather than attempt any detailed description of its operation the translation of the Ministry's own statement is included here:

> The Ministry for the Construction of Electric Power Stations is engaged in the construction of thermal, atomic, and hydroelectric power stations of regional importance, and also in the construction of power transmission lines and substations for 110–220, 400, and 500 kilovolts and higher. The Ministry has the following subdivisions, corresponding to the above tasks. These are the six Main Construction and Installation Administrations:
>
> *Glavtsentrenergostroy* (Main Administration for the Construction of Electric Power Stations of the Central Regions);
>
> *Glavvostokenergostroy* (Main Administration for the Construction of Electric Power Stations of the Eastern Regions);
>
> *Glavgidroenergostroy* (Main Administration for the Construction of Hydroelectric Power Plants);
>
> *Glavtsentrelektroset'stroy* (Main Administration for the Construction of Transmission Networks of the Central Regions); and *Glavvostokelektroset'stroy* (Main Administration for the Construction of Transmission Networks of the Eastern Regions)—all engaged in the construction of thermal, atomic, and hydroelectric power stations and high voltage transmission networks—and
>
> *Glavenergostroyprom* (Main Administration for the Electric Power Construction Industry) engaged in the administration of all plants producing construction equipment, reinforced concrete parts, and other parts required for the construction of power stations and transmission networks. Main Administrations of the Ministry carry out direct supervision of individual construction projects through the localized construction and installation trusts.
>
> The Ministry includes *Glavenergoproyekt* (Main Administration for the Design and Planning of Electric Power Plants and Networks), which administers design and scientific research institutes for the design and planning of thermal and hydroelectric power stations and high voltage transmission networks.
>
> The Ministry also includes *Glavkomplekt* (Main Procurement Administration for All Power Equipment) [not shown on chart] and *Glavsnab* (Main Supply Administration), which are engaged in the procurement of all equipment and materials for the construction of electric power stations and transmission networks.
>
> The Technical Administration implements engineering policies in the construction of power stations, and is concerned with the introduction of new machinery and methods on construction projects.
>
> The Planning and Production Administration is engaged in the planning of design-research and construction-installation operations, as well as of capital investment in the building program.

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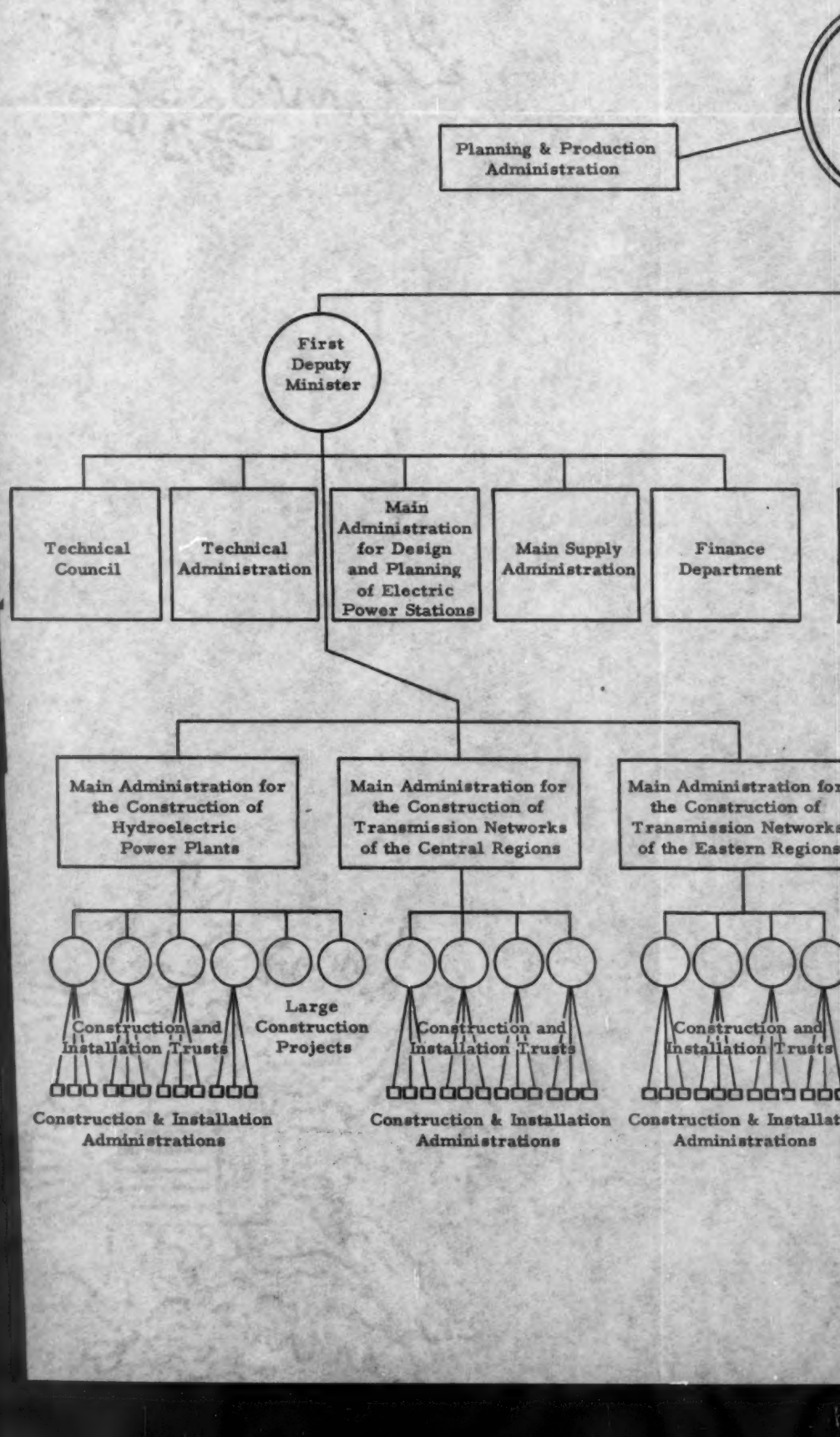
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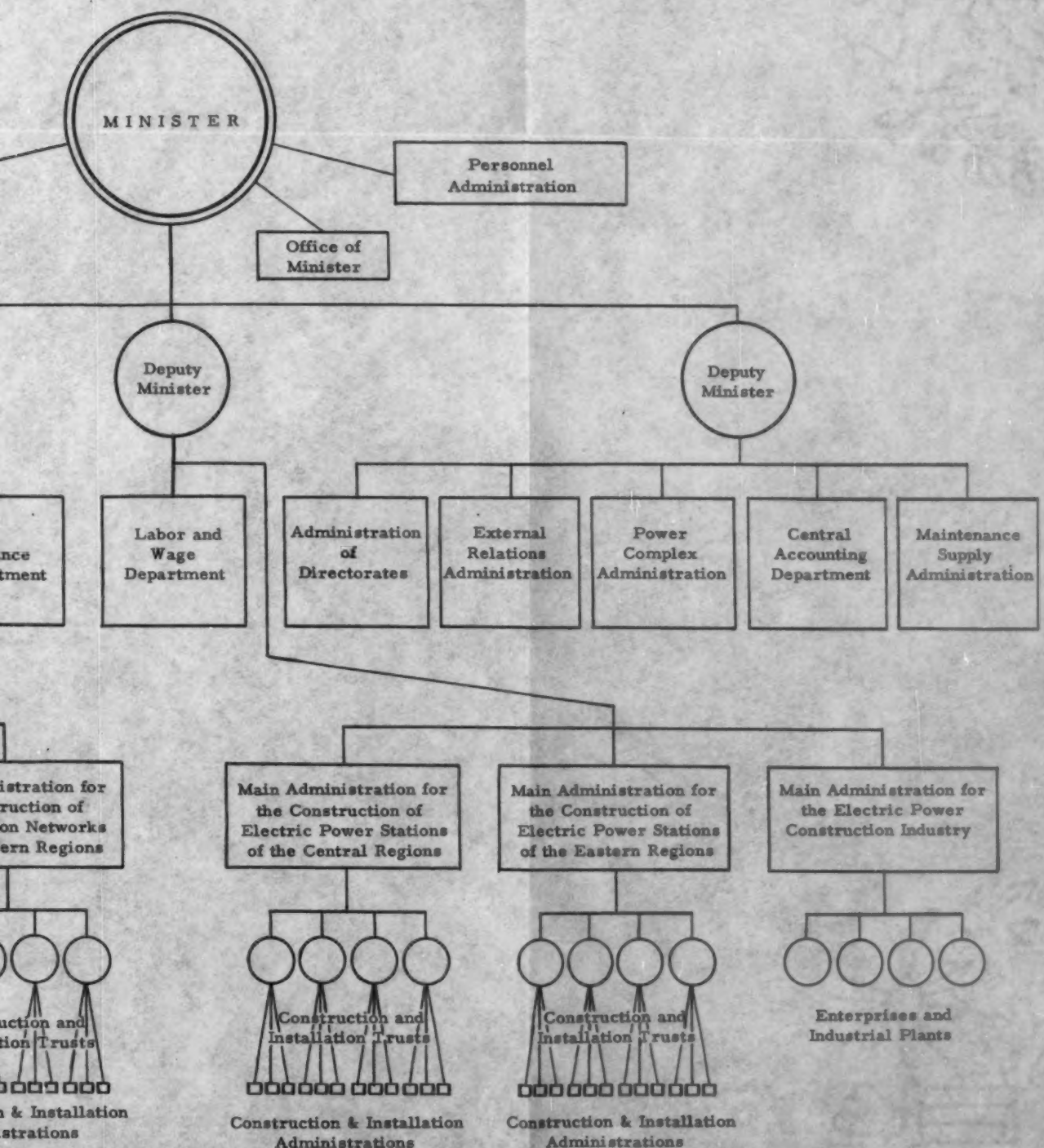
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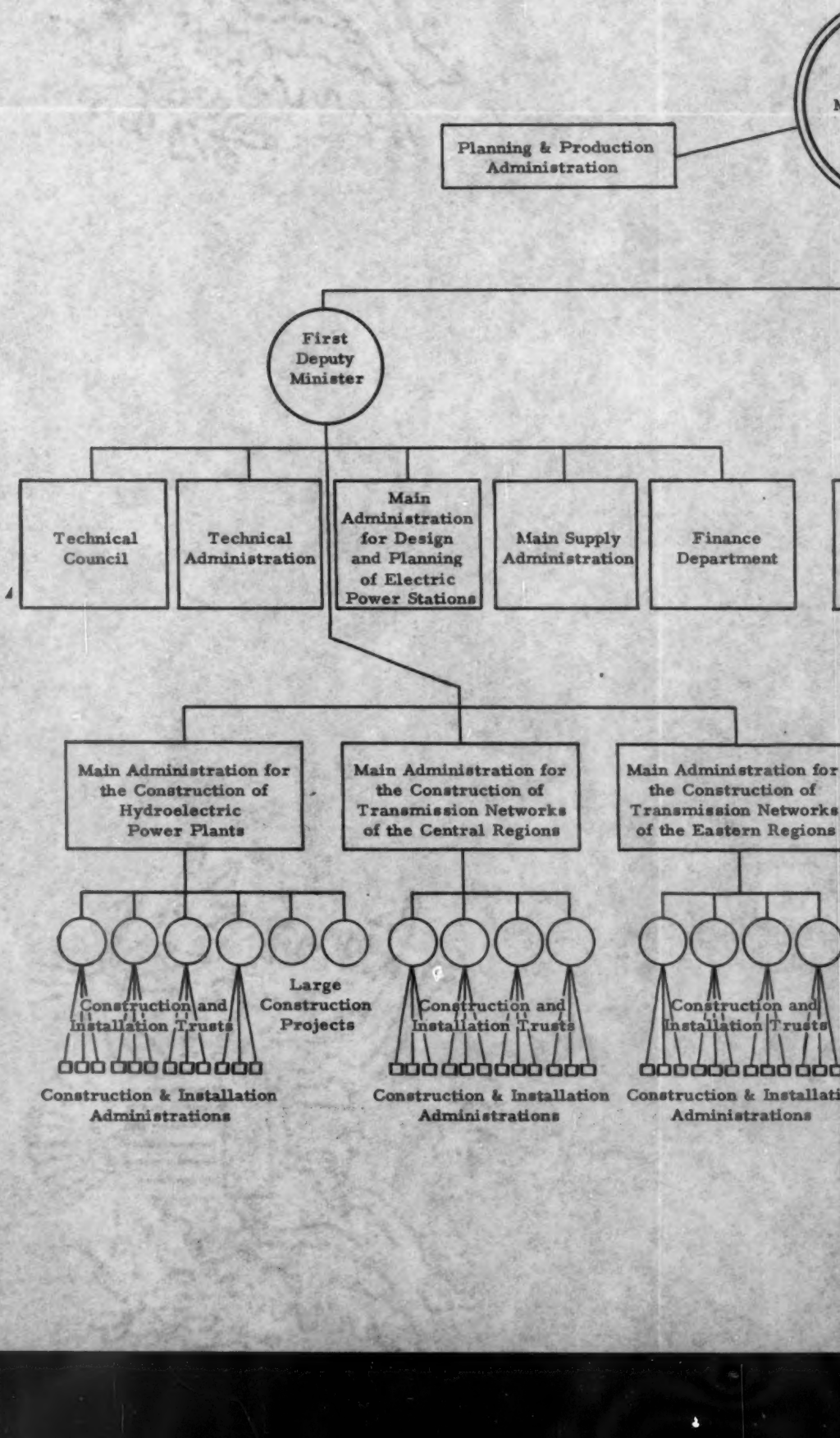
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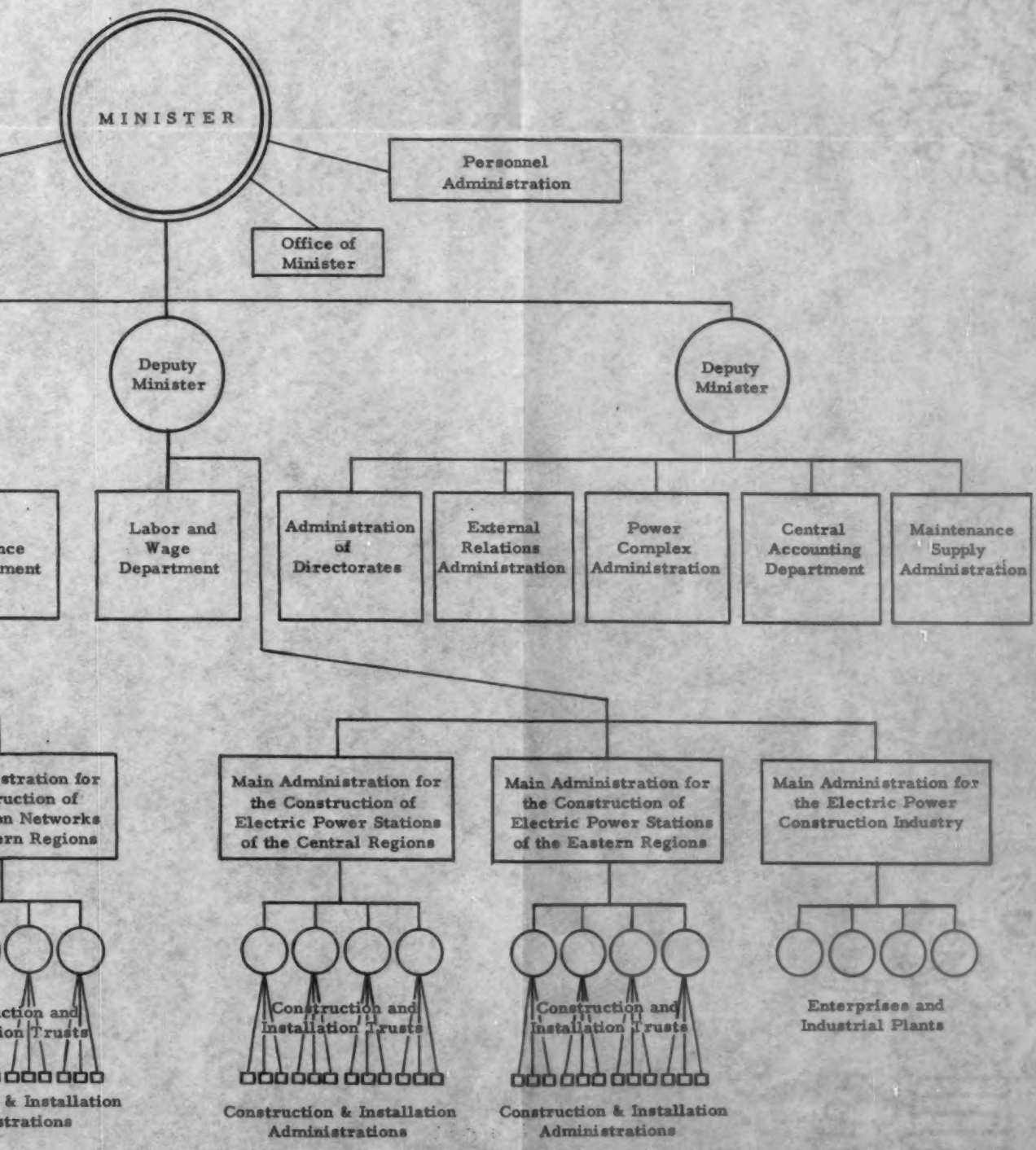
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Construction and Installation Trusts
Enterprises and Industrial Plants
Construction & Installation Administrations
Construction & Installation Administrations

As to the organizational problem, if the Ministry's function is merely to provide rapid and efficient installation of the electrical equipment supplied to it by industry, it obviously performs that function admirably, at least in the field of hydroelectric development. However, if its function is to attain or surpass the goals of the 7-year plan or any other set standard, then it suffers from the most basic administrative weakness—its authority is not coextensive with its responsibility. Nowhere on the organization chart is there an indication of any effective control by the Ministry over its source of supply, the electric equipment manufacturing industry, which is believed to be at present a much weaker component of the entire power-expansion picture than the Ministry itself.

We could hardly help but notice a few examples of this problem. For instance, at the Stalingrad project there were three generators actually on the line—apparently since the first of the year. There were five 115,000-kilowatt units completely installed, but not in operation. And why? Because their transformers had not been received until a short time before our visit. The 1959 Soviet goal for new generating capacity is 6 million kilowatts, but on October 15 Minister Novikov announced that to meet it would require the installation of 3.7 million kilowatts by the end of the year, which means that at that time the goal was less than 39 percent achieved. It should be added that the last quarter is normally by far the largest in Soviet power installation schedules; perhaps by the time this report is published it will be proclaimed that the goal has been reached, but this will clearly require a very substantial last-minute drive. In 1958 even such a final quarter drive left the 5,600,000-kilowatt goal 900,000 short of attainment.

Nor is the problem of equipment supply one of which the Power Construction Ministry personnel are unaware. It requires only a minimum of reading between the lines to infer that the Minister was at least hinting at where the responsibility would lie for any subsequent deficiencies when he said in his maiden speech after taking office, addressing the 21st Party Congress:

> We express the hope that the Soviet builders of power machinery who, jointly with us, must fulfill the tasks related to the development of power supply, headed by the sovnarkhozes and under the leadership of the party organizations, will uncover reserves and speed up the development and production of new highly thrifty equipment for electric power-plants, thus insuring that the equipment is promptly, fully, and reliably installed at the units on the building sites.—I. T. Novikov, February 2, 1959.

This problem may solve itself gradually through administrative adjustments and is quite likely to do so if the expansion goals for electrical equipment production of the 7-year plan are met. Although the overall goal for the expansion of industrial output by 1965 is a massive 80 percent, this figure is dwarfed by the goal for the expansion of electrical generating equipment production, which is supposed to reach 18 million kilowatts, an increase of 222 percent over the 1958 goal and 283 percent over actual 1958 production as evidenced by installed capacity. It is planned to expand production at the Kharkov diesel locomotive electric equipment plant alone by about 600 percent over its present productive capability of some 1,200,000 kilowatts.

ELECTRIC POWER ORGANIZATION IN THE SOVIET GOVERNMENTAL STRUCTURE

The interrelationships of the various organizations and governmental levels within the Soviet political structure are, to put it mildly, exceedingly complex even in so limited a field as electric power supply, generation, and transmission. At the risk of being accused and convicted of oversimplifying the problem, I have prepared the attached schematic diagram which presents these interrelationships as they appear on the basis of our investigations and the information obtainable and study allowable within the time schedule of this report. The relationships illustrated by this diagram will be briefly discussed in this section.

Before attempting this discussion a brief description of the Soviet politico-economic framework is necessary. The Soviet Union is divided at the present time into 104 economic regions; all economic activities in each region are controlled by the regional economic council, or "sovnarkhoz," which controls all local economic planning, allocation of resources, industrial production and electric power production, subject to the higher authority of the Council of Ministers of the local Republic and the supreme authority of the All-Union Council of Ministers in Moscow.

The authority of the sovnarkhozes may or may not be coextensive geographically with the local Republics in which they are located; there are at present 15 Soviet Socialist Republics within the Union of Soviet Socialist Republics. In the R.S.F.S.R., the Russian Soviet Federated Socialist Republic, which contains over 50 percent of the the population of the Soviet Union and comprises 74 percent of its land area, there are 68 economic regions, each with its own sovnarkhoz. The Ukrainian Soviet Socialist Republic, the most densely populated of the constituent Republics, is divided into 11 economic regions. The Kazakh S.S.R., second only to the R.S.F.S.R. in area, comprises nine economic regions, and the Uzbek S.S.R., most important economically of the Central Asia Republics, incorporates five economic regions. Each of the other 11 Republics constitutes approximately one economic region.

Initial planning for power supply starts at the level of the sovnarkhoz, which prepares both annual and longer range plans relating to all aspects of the economy of the region under its jurisdiction; with the assistance of its subordinate, the regional power board, or "energo," the sovnarkhoz prepares its estimates of future power requirements of the region and forwards them to the Council of Ministers of the Republic in which it is located, along with its suggestions for supplying those requirements.

The republican Council of Ministers considers the needs and suggestions of the sovnarkhoz or sovnarkhozes under its jurisdiction and devises the general regional economic plan, which is then prepared in detail by the republican Planning Commission charged with effectuating the policy decisions of the Council. This plan, when approved by the Council, is forwarded to the All-Union Council of Ministers, which, with the assistance of the All-Union Planning Commission, or "Gosplan," coordinates the plans of the various Republics and prepares the overall national plan.

ELECTRIC POWER ORGANIZATION IN THE SOVIET GOVERNMENTAL STRUCTURE

(Organisation Chart)

MINISTRY FOR CONSTRUCTION OF ELECTRIC POWER STATIONS
(Research, design & construction of all electric power plants and high-voltage networks)
INDUSTRIAL POWER STATIONS, SMALL MUNICIPAL & RURAL POWER STATIONS
(Operated under control of Sovnarkhozes; excess energy delivered to regional networks)
ALL-UNION COUNCIL OF MINISTERS
(Ultimate Control of Electric Power Planning & Production)
COUNCILS OF MINISTERS OF THE 15 REPUBLICS OF THE U.S.S.R.
(Regional planning & over-all control of electric power production)
REGIONAL ECONOMIC COUNCILS OF THE 104 ECONOMIC REGIONS (SOVNARKHOZES)
(Initial Planning)
(Overall operational control of all plants and disposition of power)
ALL-UNION PLANNING COMMISSION (GOSPLAN)
(Coordination of plans prepared by Republican Planning Commissions)
(Effectuation of decisions of All-Union Council of Ministers)
PLANNING COMMISSIONS OF THE 15 REPUBLICS
(Preparation of detailed plans for effectuation of decisions of Republican Councils of Ministers)
REGIONAL POWER BOARDS (ENERGOES)
(Direct operational control & maintenance of regional power networks & regional power stations)
(Chairmen members of Sovnarkhozes)
REGIONAL POWER STATIONS
(Directors members of Energoes)

Thus ultimate control of all economic planning and production, including the planning and production of electric power, rests in the All-Union Council, which for all but major questions of policy means, in effect, in Gosplan. A suboffice of Gosplan handles planning for the unification of regional power systems, interties between regional grids, and long-range plans for the eventual national power network.

Having gotten the detailed national plan for electric power development drawn up at the top of the pyramid, we now follow it back down to see how it is put into effect. We know from our previous discussion that the Ministry of Power Station Construction is going to handle all technical planning, design, and construction work for major plants and high-voltage transmission lines. Funds for this work will be allocated by Gosplan from the national treasury, just as it allocates the finances necessary for various types of industrial expansion in the separate economic regions. In response to questions we were informed that smaller stations (and presumably some of the lower voltage transmission lines) are designed by the Ministry but may be constructed either by the Ministry or by the local sovnarkhoz through its regional power board. Similarly, these smaller developments may be financed either by national funds from Gosplan or by the local sovnarkhoz using its own sources of revenue. This provides at least some of the local control and flexibility which are so necessary to meet unforeseen emergencies and changes in plans under any economic system.

Since the January 1959 reorganization the operational control of all plants in a region and the regional network is exercised by the sovnarkhoz, which also controls the disposition of the power produced. This operational control is exercised by the sovnarkhoz largely through its own energo, or regional power board, which operates and maintains the regional plants and network and whose director is a member of the sovnarkhoz. The directors of the regional power stations are members of the regional power board. Industrial power stations, small municipal and rural powerplants are controlled directly by the sovnarkhoz and wherever possible are tied into and operated in parallel with the regional network, delivering any excess power to the regional power board for integration into the system.

Nationally, 78.5 percent of all electric energy generated in 1958 was produced by the large regional powerplants, 7.5 percent by large industrial powerplants, and 14 percent by small, isolated industrial, municipal, or rural powerplants. If the last figure seems high it must be kept in mind that there are actually operating in the Soviet Union some 100,000 thermal power units and about 6,000 hydroelectric stations, most of them obviously tiny local and rural units. Incredible as this total figure may seem, it was verified by Minister Novikov himself during his February 2, 1959, address in these terms:

> Comrade delegates, it is not without interest to report to you that at present there are more than 100,000 small, low efficient electric powerplants in the country. They produce about 10 percent of the total amount of electric power, and the power they produce comes to 1 to 2 rubles (100–200 kopecks) per kilowatt-hour. About 800,000 people, operating personnel, service these stations.

At the same time the large electric powerplants which produce 90 percent of the country's total electric power at an average cost of less than 8 kopecks per kilowatt-hour have servicing personnel numbering less than 200,000.

One of the interesting areas of information concerning which there seems to be almost no information available in print relates to power exchanges and the financial accounting between and within the various sovnarkhozes and their superior organizations. In response to questions we were informed that transfers of power between neighboring sovnarkhozes are handled by agreement between them, under the direction and regulation of and subject to approval by Gosplan. Exactly how the accounting for these transfers is handled remains a mystery, but apparently it is strictly an internal accounting operation—we were informed there are no payments between sovnarkhozes. Each sovnarkhoz keeps accounts of its costs and expenditures and also of its sales and receipts, as well as its transfers to or from other sovnarkhozes; beyond these facts we must resort to conjecture.

It is easy to assume payments by the separate sovnarkhoz power systems to Gosplan of an amount adequate to repay the capital investment provided by Gosplan within the amortization period, after which the sovnarkhoz could pay its own operating and maintenance costs on the system. And if it receives power from another sovnarkhoz, it could also make a payment to Gosplan for a proportional amount of the amortization on that other sovnarkhoz' projects or system. But if there are no payments between sovnarkhozes, how does it pay its share of the other sovnarkhoz' operating and maintenance expenses—or of the amortization on any investment which that other sovnarkhoz may have financed from its own funds? This is an area for further investigation.

The question was also asked as to how power is apportioned where the network includes several economic regions. The answer received was that Gosplan prescribes the amount to be used by any region as part of the planning function previously discussed; as long as there is a need for power in any connected area each region generates its maximum locally and uses its allocated share, making the excess available to the shortage area.

We further inquired concerning what happens in the event shortages occur; that is, what is the system of priorities and which loads are dropped first? The answer was that this problem is generally controlled by the agreements between the sovnarkhozes and by Gosplan. If a region has a shortage it may appeal to Gosplan for a modification of its power allocation or its agreements with its neighbors. Since Gosplan allocates funds for both powerplant capacity and for the industrial expansion which makes additional power capacity necessary, presumably any purely local shortages are subject to eventual solution, whether or not that solution will please the local sovnarkhoz.

SOVIET TRANSMISSION SYSTEM

Except to direct attention to and confirm the information contained in the excellent Kuljian-McPhail report on the Russian transmission system, very little need be said here on the subject. The Soviet engineers are quite aware of the fact that insufficient transmission is one

of the major weaknesses of their systems, as evidenced by the relatively low plant factor at which their generation operates. That they intend to do something about it is shown by the projected rates of investment during the 7-year plan as compared with the actual expenditures during the past 7 years. The overall projected capital investment in power development during the 7-year plan is 127 billion rubles, an increase of about 70 percent over the previous 7 years; but the planned investment in transmission is expected to increase some 312 percent from 8 to 33 billion rubles.

Soviet investment in electric power facilities

[Billions of rubles]

Years	Thermal generation	Hydro generation	Transmission	Total
1952–58 (actual)	31	36	8	75
1959–65 (planned)	74	20	33	127

In the 7-year plan there will be several integrated systems created; those which were mentioned specifically to us were the European-Urals Central Asian, Central Siberian, Trans-Caucasian, and Northwest systems. The only major intersystem interconnection to be completed in the 7-year plan, we were told, is the 500-kilovolt tie between the Urals and the European grids, through Votkinsk and Chelyabinsk. However, the similar tie between the Kemerovo thermal power system serving the important Kuzbass metallurgical and coal mining area and the Krasnoyarsk-Irkutsk systems to the east would appear to be an important development. The low-cost coal of the Kemerovo area makes possible the production of 6-kopeck power there, and heavy expansion of these thermal generating plants is proposed; such a system backed up through a 500-kilovolt intertie by the less than 1-kopeck power expected from Bratsk and the 0.4-kopeck energy projected for Krasnoyarsk will be a formidable system indeed. Also of interest on the map of the 1965 transmission systems included in the Kuljian-McPhail report is the 500-kilovolt line proposed from Achinsk to the Yenisey site, a strong indication that work on that project is expected to get underway by 1965 when Bratsk will be 2 years finished and Krasnoyarsk nearing completion.

One other comment is perhaps in order concerning the subject of Soviet transmission development. As can be noted from the maps referred to, there is no high-voltage direct current transmission shown for 1965; although the Russians have repeatedly in the past stated their intention to utilize ultrahigh-voltage direct current in their trans-Siberian grid, apparently this is to be sometime after 1965 according to present plans.

This is particularly interesting because it raises the major policy question of the feasibility of advance planning based on engineering not yet developed and well in advance of world technology. The experimental Stalingrad-Donbass 800-kilovolt d.c. line was originally proposed for completion in 1958, but very little has been heard of it during the past year, and we were informed that the project is still in the research stage at the Moscow Direct Current Institute. It is a reasonable deduction that the technological developments required for the

design and production of terminal facilities for direct-current voltages of this level are providing some interesting and possibly unforeseen problems, the solution of which will be of major interest to engineers the world over.

SUMMARY

The Soviet interest and determination to overtake the United States in industrial production verges on obsession, and any discussion of the psychological, economic, or military reasons for this is beyond the scope of this report. It can safely be stated, however, that the success of the Russians in this effort will depend in a substantial degree on the efficiency and effectiveness of their organization for the supply, generation, and transmission of electric power, for modern civilization is increasingly dependent on its energy supply for its production and growth—and its energy supply is increasingly electric. Under these conditions it is pertinent to comment that between 1950 and 1958 the gross production of power in the Soviet Union as a percentage of that in the United States rose from 22 to 31 percent and by 1965 it is projected as increasing to 40 percent, if an average of Federal Power Commission and Edison Electric Institute estimates is used as the basis for U.S. projections.

The Soviet organization for electric power has ben described briefly here; it is a subject which will continue to be of major interest to the Congress and the Nation in the years ahead, and it is perhaps in order to recommend that its study—and the study of how we can improve our own equivalent organization—be continued during the foreseeable future by the two Senate committees participating in the present study, as well as by the other organizations directly interested.

HYDROELECTRIC AXIS SWINGS

(By Michael W. Straus)

The axis of world hydroelectric development is swinging from the U.S.A. to the U.S.S.R.

Considerable evidence supporting this conclusion was unexpectedly come upon in the Soviets by the Senate observers.

It has been widely recognized that American engineers and equipment manufacturers were setting the pace and leading the way in hydroelectric development not only domestically but elsewhere. Designers, builders, economic and physical survey crews were called upon to perform their tasks almost everywhere dams were built. In their wake endless shipments of vital equipment flowed overseas from American factories and American industry built by American labor. This era ran roughly through the midcentury mark of 1950. Its effects were particularly observable in the home plant grounds of the "Big Three" of American heavy electric equipment manufacturers in Schenectady, N.Y., East Pittsburgh, Pa., and Milwaukee, Wis. There anybody could read the shipping labels on trainloads of gear headed for Asia and Africa.

Specifically, this condition also prevailed at the other end of the line in Russia when Dnepro GES Dam was built in the early 1930's. This was the structure by which the U.S.S.R. entered the great hydroelectric building era, raised its own sights and proved to its own satisfaction it could step ahead in the world of hydroelectricity. This dam on the Dneper River in Ukraine was built under the instructions, design, and construction supervision of Hugh Cooper, a distinguished American engineer. All its generators and much other machinery for the structure were made in Schenectady, N.Y., by the General Electric Co. which also supervised installation. This the Senate observers heard their Soviet hosts graciously acknowledge half a hundred times during this autumn's travels.

All the current crop of great Soviet hydroelectric plants are rising on an all-Soviet foundation. The design is all Russian, the construction is all Russian, and the machinery is all Russian. That's the U.S.S.R. policy and program. The Communists are in the hydroelectric business for themselves. The Americans are out in the U.S.S.R.

The two most notable hydroelectric dams now going forward in the world, outside the U.S.S.R. are Chinese and Egyptian. They are the Ichang Gorge Dam on the Yangtze River in eastern Asia and Aswan Dam on the Nile River in northeast Africa. American engineers either did, or sought to, provide the design and construction of each at one time. American manufacturers in each instance took many steps to secure the huge generator and machinery contracts. They will not. In each case others are now entrenched on the jobs—chiefly Russians—and the Americans might as well find out why now.

CHINA'S (AND RUSSIA'S) GIANT ICHANG GORGE PROJECT

In the early 1940's John Lucien Savage, then world famous chief dam design engineer of the U.S. Bureau of Reclamation, was detailed to the State Department to go to China—now Red mainland China. This was at the time the United States was doing everything to keep Chiang Kai-shek in the war and one day Chiang asked for Savage to advise what should be done to develop the great Yangtze River. Savage personally surveyed the job, returned to Denver accompanied by some 35 Chinese engineers and proceeded to draw up design and blueprints for the world's greatest dam which were regularly dispatched to Chiang's government, then established in Chungking. These plans which were accepted provided for an unprecedented multiple-purpose structure that would make 10,000-ton navigation possible from the ocean to Chungking, by flood control and irrigation approximately double the rice crop on the Shanghai plain and provide power for the lamps of China. Savage designed 15 million kw capacity into that project and an announcement thereof was widely and bitterly criticized as "visionary" and "impractical" on the basis that nobody would want such power.

Even though an engineer more than a sociologist or economist, Savage stood his ground. He agreed that introduction of such electrical energy among 650 million people would produce "interesting" results—all of which he felt would be beneficial to the world. But that argument became moot shortly because the United States lost its dam client, Chiang, when he lost his Yangtze River. When he set up on the island of Formosa for understandable reasons he lost interest in the project, and the American planning contract, which called for American equipment, was suspended. In the intervening years the Yangtze faded behind the Bamboo Curtain. Nobody knew what the Red Chinese were doing with their plans for their great river and one could not find out in Washington, which also lost its Chinese mainland contacts as new management took over. Thus the status of the Ichang Dam project—the biggest of all time—became the major mystery of the dam-building world.

It ceased to be a mystery when Senate observers solved it in the U.S.S.R. on September 22, 1959, in a testing laboratory outside Moscow. There Chief Design Engineer Malishev mentioned to the observers his recent tour of duty in China. Inquiry established he had been there as a "consultant" on the Yangtze dam. So had 40 other top Russian technicians for from 1 to 6 years. Five of these "consultants" were subsequently found in five different places in the U.S.S.R. and separately interviewed. All talked freely and proudly of their contribution to the Yangtze dam. They were amazed at the American's lack of information and their eyewitness stories gibed and cross-checked. Each knew all about the Savage-American plan which in fact was the starting point of their studies for their Communist neighbor and ally. All felt sure the dam would be built in their lifetimes and be the all-time greatest anywhere but strictly a Communist Chinese-Russian production. The U.S.S.R. had taken over in place of the U.S.A.

They said they had preserved the navigation, flood control and irrigation features of the Savage-American plan they felt well justified but they had felt impelled to "modify" the power capacity which they were sure was "incorrect."

Their "modification," accepted by their Chinese colleagues, had consisted of increasing the power capacity, once widely attacked as "fantastically" large. Where Savage specified 15 million kw capacity, the Communists have raised the ante to 25 million kw in the "first stage" later to be lifted to 40 million kw capacity in the "second stage." Relatively 25 million kw capacity means just over one dozen Grand Coulee dams, power productionwise, rolled into one dam in one gorge inside China and that's the way it will be built, the Russian "consultants" agreed.

Just before quitting the U.S.S.R. the Senate observers came upon the designs for the generators of the great Yangtze powerplant in the Electrosila generator-manufacturing plant in Leningrad. They call for 50 identical generators each the largest anywhere. The Soviet engineers expect to build them in Leningrad.

EGYPT'S (AND RUSSIA'S) ASWAN DAM

The other specific on the swing of the world hydroelectric axis resulted from an inquiry regarding a test model viewed in a laboratory outside Moscow. It developed the model was built there to test river-flow currents and resultant foundation condition at Aswan Dam on Egypt's Nile River. The Communist conclusion derived from this test, which will fix the type of structure to be built, had been accepted by the Egyptians. The U.S.S.R. contract with Nasser for Aswan, over which a war was fought and the Suez Canal seized, only provides for tests, design, and blueprints for the dam plus a construction plan. There was, as yet, no Egyptian–U.S.S.R. contract providing for Soviet supervision of the construction of the Arab great hope.

But subsequently the observers encountered elsewhere Ivan Kozmin, the Russian construction engineer who built Kuybyshev Dam. Asked what he was doing with his talents now, he explained he had been quietly designated by the U.S.S.R. as construction engineer for Aswan Dam. And in Leningrad they are designing generators for Aswan. Doubt as to who is to control the vast Nile construction is limited in Moscow.

Soviet technicians are established in control of much dam building elsewhere in Asia, Africa, and Eastern Europe. They say they are not engaged in the Western Hemisphere. They are prevalent in China where they report 236 hydroelectric dams rising. They have signed a contract to build a big generator plant in India, for India's big development program.

The director of Electrosila, the U.S.S.R. mother generator plant (which in the 19th century manufactured articles only according to German drawings supplied by the Siemans-Schuckert Co.), says he can make just about anything in any quantity since his organization has completed big plants in remote (including Siberian) cities.

Among the demands he is prepared to meet are all generator requirements for the vast Russian program. He likes to build bigger equipment in his state plant because he thinks it more efficient. At the moment he says Electrosila furnishes heavy power equipment to China, Poland, India, Finland, and 17 other nations in Asia and Africa—some of which are satellites. Much of this machinery is installed in areas once supplied by American manufacturers.

Those are some reasons it appears the hydroelectric axis is swinging or has swung from the U.S.A. to the U.S.S.R.

RIVER DEVELOPMENT IN THE U.S.S.R.

(By Theo W. Sneed)

The water resources of the U.S.S.R. are the largest in the world, and the development of such resources has been given a very high priority in the long-range planning of the economy of that nation. Remarkable growth in this development has been attained since the end of World War II, and a tremendous increase in this activity is proposed during the present 7-year plan, which ends in 1965.

In the development of the water resources of the Soviet Union, priority is given to the production of hydroelectric power, and there is no contradiction in the use of water for such purpose. However, the principle of multiple-purpose development of an entire river basin is followed in the design scheme for utilization of the water resources from an economical and technical point of view. The priority of use and development is: (1) Hydroelectric power, (2) navigation, (3) irrigation, (4) flood control, (5) fish, wildlife, and recreation, and (6) water supply.

Selection of projects is based on the economics and conditions of the region. The projects are constructed by force account. Storage is normally developed in the upper reaches of a basin to assist in development of the projects in the lower reaches.

Most of the rivers in the U.S.S.R. flow through relatively flat terrain. In the European region, the majority of the streams have a high bluff on one bank and a wide flood plain on the other, which requires construction of high earth dams of great length. These streams are alluvial in character, with foundations of sand and gravel, which present complicated construction details. Conditions on the Siberian rivers are similar to those in America, in that many damsites are located in gorge sections, with rock foundations and abutments. Flows in the streams are large, but in many cases seasonally erratic, necessitating provision of reservoir storage. Soviet streams flowing north into the Arctic Ocean cannot be fully utilized over their entire length because of ice conditions.

The hydroelectric power potential of the Soviet Union is large, with an estimated potential capacity of 340 million kilowatts, with only about 3 percent now developed. About 85 percent of the total water power potential is in that portion of Russia in Asia and 15 percent in European Russia. Major developments have taken place in the European areas, but emphasis is now taking place in the Asiatic regions.

The 80,000-mile inland waterway system of the U.S.S.R. handles only 5.4 percent of the total freight of the country but is very important in handling bulk commodities, such as oil, timber, and construction materials, over the long lengths of the navigable rivers. The development of these natural traffic routes is reduced somewhat by the movement of freight traffic which is normal in an east-west

direction, while the rivers for the most part flow in a north-south direction. Navigation on many of the streams is limited by ice conditions to a 4- to 6-month period, and varying climatic conditions over the length of some streams may limit navigation to short stretches. Plans are underway to modernize some of the old obsolete navigation projects.

Irrigation development in nonproductive arid areas has been practiced in Russia since the days of the czars. The larger irrigated areas are found in the Transcaucasia and in the arid areas of central Asia, although the largest irrigated areas recently added are in south Ukraine. Cotton is the principal field crop grown under irrigation, but rice, sugar beets, alfalfa, tobacco, grain crops, nuts, fruit, melons, and vegetables are also grown under irrigation, or where the water supply is supplemented by irrigation. The largest amount of land now being placed under irrigation is in small tracts, by reconstruction and rehabilitation of older irrigation systems. This is complicated in certain regions where the tributaries of streams lose themselves in the desert areas and where shifting sands fill the lakes and tributaries. Irrigation is, however, one of the valuable functions of multiple-purpose development, and, while now being prosecuted more slowly than other features, is nevertheless available for exploitation at any time deemed feasible and desirable.

Flood control is not a major problem in the Soviet Union. Floods are seasonal, high, and regular, and there has been little development in the flood plains of the rivers. Flood losses are either absorbed or flood zoning is decreed to eliminate the flood hazard. Levees and floodwalls have been constructed around urban areas, particularly where the reservoirs encroach on such areas, and improved concrete-lined channels, supplemented by dikes or floodwalls, have been provided to carry streams through many of the older cities located thereon. The large multiple-purpose reservoirs constructed to provide regulation of streamflow will have an inherent value for flood-control purposes.

Rows of trees have been planted along practically all the main highways in the Soviet Union, and reforestation, contour plowing, terracing, and planting of shelter belts is practiced in many areas. There are no general programs for soil conservation, flood prevention, and watershed protection in the U.S.S.R. as we know them.

The fishery resources of the streams of the Soviet Union are very valuable. Protection of fish and wildlife is considered an important problem, but not as important as in our Pacific Northwest. They do not have large runs of migratory and anadromous fish in the streams. Provisions are made for passing migratory fish over dams where needed, and plans are being considered to increase the development and propagation of fish in the reservoirs by construction of hatcheries. The construction of a fish elevator at the Tsimlyanskaya Dam on the Don River has proved very valuable, as during July and August about 1 ton of fish per lift is raised over the dam. This has permitted development of a thriving fish industry in the Tsimlyanskaya Sea above the dam. Fish elevators are being installed in the Stalingrad Dam.

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Domestic water by the simplified method of tank, wagon, and horse comes from the Don River.

Water resource development projects in the U.S.S.R., include both recreation and water supply. The population is not concentrated along the seacoasts. The short warm-weather season in most of the populated areas decreases the recreational values of resource projects. In addition, serious water pollution, particularly from industrial sources, reduces the use of certain water sources for water supply, recreational purposes, and fish and wildlife propagation. Several of the reservoirs have been developed for boating and bathing. The summit reservoir of the Moscow-Volga Canal also serves as a water supply reservoir for the city of Moscow.

The hydroelectric power developments in the U.S.S.R., thus solve not only the power problems, but also the problems of water transportation, irrigation, flood control, fish and wildlife, recreation, and water supply. For example, the power projects in central Asia in addition to the production of electric power will provide for irrigation of hundreds of thousands of acres of arid and barren land. Construction of the planned projects on the Volga, Dnieper, and other rivers will transform these streams into deepwater transportation

routes, and provide routes connecting the Black, Caspian, White, and Baltic Seas. Extensive possibilities will also be opened for irrigating arid regions of the Volga and the southern Ukraine.

HYDROELECTRIC POWER

Great attention is now being paid to electrification of the Soviet Union. Before the Russian revolution there was no hydroelectric power development in the U.S.S.R., and a total capacity of 1 million kilowatts of thermal power with a production of about 2 billion kilowatt-hours annually. After 1920, plans were made to develop the economy of the country, of which electricity was regarded as the chief basis. Plans were made to construct development of 1.7 million kilowatts, which was successfully achieved.

The Soviet Union now has 220 thermal plants with a total installation of 42 million kilowatts, and 120 hydroelectric plants with an installation of 11 million kilowatts. In 1958 these plants developed 233 billion kilowatt-hours, of which 20 percent was hydroelectric. Under the present 7-year plan, it is proposed to increase power production by 1965 to 520 billion killowatt-hours, to meet the needs of the industry and a growing economy. The total planned installation will then be 113 million kilowatts, an increase of 60 million kilowatts, of which total 23 million will be hydroelectric, and 90 million thermal. It is proposed that 79.3 percent of the energy will be used by industry, 15.5 percent residential, and 5.2 percent by transport. During the preceding 7 years (1952 to 1958) some 7.4 million kilowatts were put into operation. Over 100 hydroelectric power projects varying in capacities from 10,000 to 7 million kilowatts, with individual generating units up to 500,000 kilowatts, are now under construction or being planned, including associated and related appurtenances to permit full and coordinated multiple-purpose development of economical functions needed at this time.

NAVIGATION

Although the development of the inland waterways in the Soviet Union is subservient to the development of hydroelectric power at the present time, such development has proceeded apace. The 80,000-mile inland waterway system includes many open-river routes along undeveloped streams, and obsolete and minor canals dating back for many years. As new routes are opened, others are abandoned, and the total length has changed little. Many of the principal rivers and lakes have been improved and modernized for furthering navigation, including certain ones in Siberia.

Much of this improvement has been occasioned by the construction of large multiple-purpose projects for power and other purposes, rather than for navigation only. As estimated, only 5.4 percent of total freight in the Soviet Union is transported over the inland waterway system of the Soviet Union; yet it is of great importance in supplementing the railroad system. The freight movement has doubled since 1950, and an increase of 60 percent is planned by 1965. The

increase in freight movement by inland water transport is shown in the following table:

Inland water transport, U.S.S.R.

Year	Length of waterways (thousand kilometers)	Total freight tonnage (million tons)	Total freight movement (billion ton-kilometers)	Percent total freight movement
1928	71.6	18.3	15.9	13.3
1940	107.3	72.9	35.9	7.4
1950	130.2	91.5	45.9	6.4
1955	131.9	139.1	67.4	5.8
1956	132.8	146.8	70.2	5.4
1957		159.2	76.4	5.2
1958	134.4	178.3	85.5	5.4
1965 (planned)	141.4	267.5	140.0	5.5

In comparing the inland waterway system of the Soviet Union with that of the United States, the significant feature is not the length—80,000 miles as compared with about 23,000 in the United States—but rather the commerce moved. This comparison of waterway traffic by tonnage and distances is indicated in the following tabulation:

Inland waterway commerce

	Tonnage (millions of short tons)		Water transport (billions of ton-miles)	
	U.S.S.R.	U.S.	U.S.S.R.	U.S.
1928	18.3	475	10	75
1950	91.5	821	29	166
1956	146.8	1,093	48	220
1958	178.3	1,170	53	240

The Volga River and its tributaries is the most important waterway in the Soviet Union from the standpoint of movement of traffic. Completion of the system of 12 dams on the Volga, of which 8 are completed or under construction, will provide a channel 10 feet or deeper over 2,000 miles of the main stream. From the Volga, a canal extends 63 miles westward to the upper end of a 160-mile long reservoir on the Don River. There are 13 modern locks in the canal and 2 at the dam forming the reservoir on the Don. The project also provides power and will furnish water for the planned irrigation of almost 5 million acres of land. This canal provides a connection between the Black and Caspian Seas, and will permit the building of submarines and small craft in large shipbuilding yards along the Volga. The Kama River, tributary of the Volga, extends into the Ural Mountains, and serves important industrial areas.

The Volga River is connected with Moscow by a 75-mile canal with large locks, 100 by 1,000 feet, with 18 feet depth over the sills. A 300-mile canal, with small and old locks, now connects the Volga River system near Moscow, through Lake Onega with the more modern Stalin Canal system which joins the Baltic and White Seas. Reconstruction of the Moscow-Lake Onega Canal is planned, and by 1965 will complete a waterway with capacity equal to the Stalin Canal and the Volga-Don Canal, which will provide an inland waterway

system connecting the Black, Caspian, Baltic, and White Seas, and capable of carrying smaller types of seagoing vessels, including submarines.

On the Dnieper River, five dams, all complete or under construction will provide 680 miles of 10-foot channel on the main stream, and additional projects proposed will provide 1,600 miles of navigable waterways on tributaries of the Dnieper.

The major products moved by water transportation in the Soviet Union are oil and timber products, primarily rafting of logs. Port development does not apear to be extensive, although it is increasing, and water shipment of grain is low compared with other products. The improvement of navigation routes by the construction of power dams will require modernization of the inland waterway fleet. Locks in most of the power dams are from 90 to 100 feet wide, 900 to 1,000 feet long, with sill depths of 10 to 18 feet, and will accommodate existing vessels, and large rafts of logs. Considerable amounts of local and short-haul commerce is handled on the streams and lakes, and a large number of passengers travel locally by boat.

The amounts of traffic moved on the major inland waterway routes are as follows:

Commerce moved, 1955

Stream	Billion ton-kilometers	Kilometer length
Volga River, including Volga-Don Canal	33.5	3,668
Kama River	8.1	1,216
Severnaya Dvina Canal and connections	4.2	1,304
Dnieper River	4.0	2,285
Other streams	17.6	123,104

The tonnage moved on the inland waterway system of the U.S.S.R., broken down between products, is as follows:

Freight movements by water transportation, 1956

Product	Millions of tons
Petroleum products	15.0
Timber products	72.4
Grain	5.6
Salt	2.0
Coal	8.8
Construction materials	33.0
Miscellaneous	10.0
Total	146.8

Waterway traffic in the Soviet Union has not increased as rapidly as rail transport. This is largely due to transportation rates, which in many cases were higher for water transport than for rail transport between certain points. New transport rates established for the 1957 navigation season failed to increase the use of water transportation to a marked degree. In most cases the waterway distances between points are much longer than the rail distances. Many of the navigation facilities are obsolete or in a bad state of repair and excessive maintenance work is required. Construction of bank protection works, groins, dikes, and other remedial measures are carried out at certain

locations, but such work is not extensive. A large amount of maintenance dredging to keep the channels open is necessary on the Volga and Dnieper Rivers, with a small amount on the lower Don.

VOLGA-DON CANAL

The creation of a waterway link between the Volga and Don Rivers was one of the earliest of Russian dreams, first having been proposed at the end of the 16th century. This project was also one of the earliest major works considered by the Soviet regime; in 1918, Lenin advocated construction of a Volga-Don Canal and, in 1927, an official commission was appointed to investigate the route. Progress was interrupted by the war; in 1949, however, actual construction was begun and the canal was completed in July 1952.

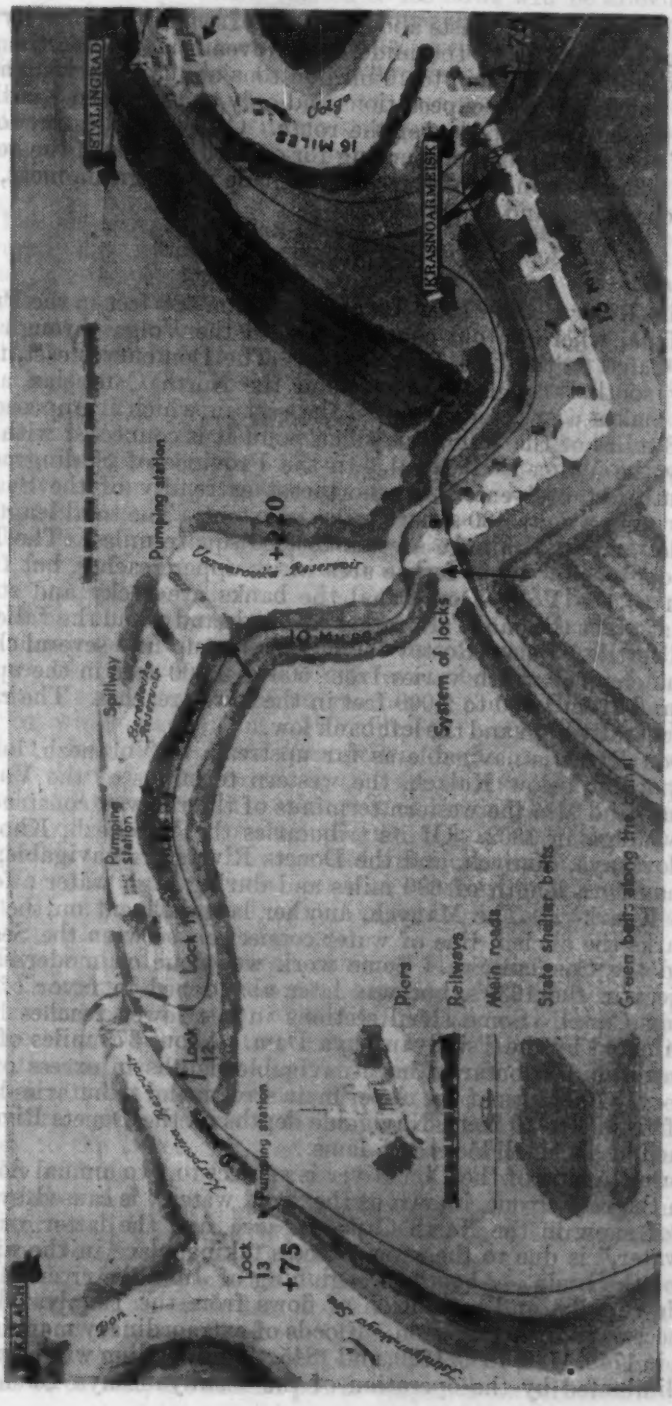
The canal is 62.7 miles (101 kilometers) long, extending from Krasnoarmeysk on the Volga (16 miles south of the river passenger station at Stalingrad) to the Tsimlyanskaya Reservoir on the Don. Existing waterways were utilized for 28 miles of its length while a new channel was constructed over remaining distance.

At the canal's entrance, the surface of the Volga is approximately 75 feet below sea level. The canal rises nearly 300 feet, by means of nine locks in its first 13 miles, to its summit reach where the surface level is about 220 feet. The summit reach is called the Varvarovka Reservoir and extends approximately 10 miles. The western slope is less steep. Through the 10th lock, it descends into the 5½-mile long Bereslavka Reservoir, then continues for 25 miles through a canal and the 11th and 12th locks, to reach the Karpovka Reservoir. It traverses this reservoir for 9 miles before descending through the 13th lock into the giant Tsimlyanskaya Reservoir on the Don River about 150 feet below the canal's summit (70 feet above sea level).

This reservoir is impounded by a 9-mile-long dam across the Don River some 160 miles below the western end of the Volga-Don Canal. Two locks and a bypass canal enable vessels to pass the Tsimlyanskaya Dam; these locks are called the 14th and 15th locks of the Volga-Don Canal.

All of the locks are similar. Each is about 500 feet long and 60 feet wide with an average lift of about 30 feet and have depths over sills of about 13 feet. Locking time is reported as from 7 to 8 minutes to 12 to 15 minutes.

A 164,000-kilowatt powerplant at the Tsimlyanskaya Dam furnishes the power used to pump water from the upper end of the reservoir to the canal's summit reach. This is necessary because the natural drainage into the summit reach is insufficient to provide the water needed for lockage. Three pumping stations have been provided, the Karpovka station near lock 13, the Marinovka station near lock 11, and the Varvarovka near lock 10. Each station can transfer 45 cubic meters of water per second; 251 million cubic meters per annum are required to operate the locks. Additional water is provided for irrigation.



Plan of the Volga-Don Shipping Canal.

The navigation season lasts about 225 days from approximately the beginning of April until the middle of November. It is estimated that the canal can handle 9 to 10 million tons annually; traffic, however, has not lived up to expectations and only an estimated 3 million tons are presently shipped over the route. Cargo consists predominantly of coal and timber, accounting for over 75 percent of the goods shipped. The remainder of the cargo is made up of grain, meat, petroleum, chemicals, and machinery.

DON RIVER

The Don River rises in Lake Ivan at elevation 580 feet in the Province of Tula, where an old connection with the Volga through the Yepifan Canal to the Upa River exists. The Don curves east, then generally south through Voronezh and the North Caucasian area, where it makes a sweeping loop to the east in which it approaches within 48 miles of the Volga, at which point it is connected with the Volga by the Volga-Don Canal. In the Province of Stalingrad it turns southwest and enters the northeast extremity of the Sea of Azov, forming a delta 130 square miles in extent. The total length is 1,325 miles and its drainage area is 166,000 square miles. The Don flows through a low-lying fertile area in its upper reaches, but from Voronezh to the Volga-Don Canal the banks are rocky and steep. Below that point the banks are rather low and sandy, and the valley is wide and fertile. Below Rostov the Don breaks up into several channels. The channel width varies from 500 to 1,000 feet in the upper reaches, and from 1,000 to 2,000 feet in the lower reaches. The right bank is generally high and the left bank low.

The Don River is navigable as far upstream as Voronezh, but is more important below Kalach, the western terminus of the Volga-Don Canal, and also the western terminus of the railway constructed from the Volga in 1862. Of its tributaries the Voronezh, Khoper, Medvyedovskaya, Manych, and the Donets Rivers are navigable, the Donets having a length of 680 miles and during high water affords access to Kharkov. The Manych, another large affluent on the left bank, marks the ancient line of water connection between the Sea of Azov and the Caspian Sea. Some work was done on modernizing this project in the 1930's, but was later abandoned in favor of the Volga-Don Canal. Some shoal sections in the lower reaches have been eliminated by the Tsimlyanskaya Dam. About 375 miles of the main stream and tributaries have navigable depths in excess of 10 feet, and over 700 miles of the upper main stream and tributaries have depths of from 3 to 10 feet. Navigable depths on the Donets River is maintained by six small locks and dams.

The lower section of the Don River is subject to two annual floods, of which the earlier one, known as the "cold water," is caused by the melting of snow in the North Caucasus area, and the latter, or the "warm water," is due to the same process taking place in the upper portion of the basin. About the beginning of June the river begins to subside rapidly, and regulation of flows from the Tsimlyanskaya Dam is necessary for navigation. Floods of extraordinary magnitude occurred in 1748, 1786, 1805, 1820, and 1845. This flooding will be practically eliminated by the operation of the Tsmilyanskaya Dam and

Reservoir, and problems related to ice flows will be alleviated. The river is usually closed by ice from November or December to March or April. At Aksai in the delta, the Don remains open on an average of 250 days of the year. The river supports a large fishing population who send salt fish, salmon, herring, and caviar all over Russia. The valley is favorable to vine cultivation and "Don Champagne" is in great demand.

DNIEPER RIVER

The Dnieper River, one of the largest European rivers, rises in a swampy district in Smolensk Province at the foot of the Valdai Hills near the source of the Volga and Western Dvina. It is about 1,410 miles long, drains an area of 202,140 square miles, has a fall of 622 feet, and an annual flow of about 4 million acre-feet. It flows through undulating country in the upper reaches and through the fertile plains of Chernigov and Kiev. About 45 miles south of Dnepr GES it crosses a granite offshoot of the Carpathian Mountains where a succession of rapids formerly existed for a distance of 25 miles through which the river dropped 155 feet. The Dnieprovskaya power project covered the rapid section of the river. The river enters the Black Sea at Kherson through a considerable estuary.

The banks are generally high on one side and the widths vary from 500 feet to 1 mile. The channel in the upper reaches is frequently interrupted by shallows. The Berezina and Pripet Rivers on the right bank and the Sozh and Desna on the left bank are navigable. Navigation extends up the main stream to Dorogobuzh, with depths in excess of 10 feet for about 660 miles to above Kiev, and log rafts are floated down from the upper reaches of the main stream and tributaries, which have about 1,500 miles of navigable channels of from 3 to 10 feet depths. An attempt was made to improve the Dnieper River channel at the rapids section as early as 1732, but a serious obstacle still existed until construction of the dam near Zaporozh'ye. By means of the Dnieper-Bug (Kings) Canal and the Berezina and Oginskiy Canals, the Dnieper had water connections to the Baltic Sea. At Kiev the river is free of ice on an average of 234 days and at Kherson 277 days. In the estuaries, the fishing industry provides employment to a large number of people.

It is planned to develop a chain of 14 multiple-purpose projects in the Dnieper Basin, with a total capacity of 3.3 million kilowatts, and an annual power output of 10.4 billion kilowatt-hours. Six of these projects will be concentrated in the lower reaches of the Dnieper below the confluence of the Pripet River, of which two are complete and two are under construction. Upon the completion of the proposed projects, a deep waterway for navigation will be available from above Kiev to the Black Sea, and on the tributaries, with a total of 1,600 miles with depths in excess of 10 feet. They will make available an assured water supply for the adjoining industrial regions, and for irrigation of the arid steppes of the southern Ukraine and northern Crimea totaling about 8.5 million acres.

The Kakhovka project is the lowest step in the Dnieper development. It consists of an earth dam about 2.5 miles long and 98 feet high with a navigation lock. The power installation consists of six 52,000-kilowatt generating units, a total of 312,000 kilowatts. Operating on a head of 54 feet, the annual power output is 1.4 billion kilowatt-hours.

The first three units were placed in operation in 1955 and the other three in 1956. Dikes totaling 19 miles in length, pumping stations, and other installations were constructed to prevent flooding of industries and populated areas in the vicinity of the reservoir. The project will provide power to industry and agriculture in the southern Ukraine, provide deepwater navigation 100 miles upstream, and play an important role in the irrigation of large arid lands in southern Russia.

The Dnepro GES project on the Dnieper River at Zaporozh'ye was the first large hydroelectric project constructed in the U.S.S.R. It consists of a concrete dam about 0.8 mile long and 198 feet high, with a three-chamber navigation lock. The power installation consists of nine generating units of 72,200 kilowatts each, a total of 650,000 kilowatts. Operating on a head of 126 feet, the annual power output is 3.1 billion kilowatt-hours. Upon completion of the Kremenchug project upstream, it is planned to expand the capacity of this project by adding six additional 125,000 kilowatt generating units in a separate plant on the left bank, or 750,000 kilowatts, which will bring its total capacity to 1.4 million kilowatts. This project was completed in 1932, was demolished during World War II, but was restored and resumed operation in 1947. This project eliminated the former rapids in the river, and in spite of the high head, the reservoir area is not large. It will permit navigation about 100 miles upstream, and a large port has been constructed in its headwater reaches. It operates in the unified southern power system.

The project on the Dnieper River at Dnieprodzerzshinsk is under construction. The work on the project is facilitated by the proximity of industrial enterprises, power supply, highway network, and the use of local labor, housing, and the social and communal facilities of the city. The project consists of an earth dam with concrete spillway dam having a total length of 21 miles, and a height of 72 feet, of which 18 miles are dikes with heights up to 50 feet which protect the flood lands of the Dnieper and Orel River Valleys. A one-chamber navigation lock with a railroad and highway across the top is being provided. The power installation will consist of eight generating units of 43,550 kilowatts capacity each, to total of 350,000 kilowatts, which, operating on a head of 42 feet, will produce 1.25 billion kilowatt-hours annually. The plant will operate primarily on the flow regulated by the Kremenchug project, as its own reservoir will provide only a daily storage.

The Kremenchug project is under construction near the town of the same name. The project consists of an earth dam with concrete spillway section having an overall length of 7.5 miles and a height of 102 feet, with a navigational lock having a lift of 60 feet with a 3-mile approach canal. The power installation will consist of 12 generating units of 52,500 kilowatts each, a total capacity of 625,000 kilowatts, which will have an annual power output of 1.5 billion kilowatt-hours operating on a head of 55 feet. No generator room will be provided, the generators being installed under special hoods. The Kremenchug project is the most important step in the development of the Dnieper Cascade, due to its large storage reservoir, with a volume of 11 million acre-feet, and 150 miles long, sufficient for multiannual flow regulation. This storage will be used for power generation four

times and will permit an increase in the capacities and power output of the downstream plants, and reduce their flood discharges. Floodwaters that formerly discharged will be beneficially used. Three generating units of the Kremenchug plant are expected to be placed in operation in 1959, five in 1960, and the remainder in 1961.

The proposed Kanev and Kiev hydroelectric power projects above Kremenchug are now being planned. Their power heads will be about 40 feet each, with installations of about 200,000 kilowatts each. They will be important links in providing a deep waterway for 660 miles from above Kiev to Kherson, and assist in developing the power potential of the lower Dnieper River, thus providing power for the industries and agriculture of southern Russia.

YUZHNYY BUG RIVER

The Yuzhnyy Bug River rises in the Avratin Hills near the Polish frontier and flows south through Podolskaya to enter the lagoon into which the Dnieper River also discharges. The upper reaches are beset by rapids and the lower reaches by sandbanks and rocky reaches which restrict navigation. Depths in excess of 10 feet are available for 20 miles above its mouth to Nikolayev, and for lesser depths for a few miles above that point.

DNIESTER RIVER

The Dniester River rises on the northern slope of the Carpathian Mountains in former Poland territory and for 150 miles from Zaleszczyki to Karmazy is the boundary between Bessarabia and Ukrainia. It drains an area of 29,670 square miles. The average width of the channel is from 500 to 750 feet, but in some places is 1,400 feet wide and very meandering. The depth varies and the curent is rapid. The navigable portion is interrupted by a granite spur from the Carpathians which form the Yampol' Rapids. Ordinary river craft can negotiate these rapids by a natural channel on the left side and a larger and deeper artificial channel on the right side. The rapids form a barrier to passage of most steamboats. The river enters the Black Sea by several arms, passing through a shallow lagoon a few miles southwest of Odessa. The river is subject to two periodical floods, one in the latter part of February or March caused by breaking up of the ice, and the latter about June caused by the melting snows in the Carpathians. The spring flood inundates vineyards and gardens in the lower reaches. In some years the water is so low that navigation ceases and in other years it continues without interruption. Improvements made have increased traffic to tap regions of great productiveness, especially cereals and timber. Fish in the lower reaches are a valuable resource. Depths of from 4 to 10 feet are available for about 300 miles, with lesser depths on the main stream and tributaries available for rafting and small craft.

VOLGA RIVER

The Volga River is the largest and longest river in Europe, having a length of 2,325 miles and a drainage area of 563,300 square miles, with a discharge at Stalingrad of 300,000 cubic feet per second. The Volga

Basin includes central and eastern and a part of southeastern Russia in Europe. The Volga rises on the Valdai Plateau at an elevation of 665 feet, flows through several small lakes, and after being joined by the Runa, enters Lake Volga. Below that lake is a dam storing about 30,000 acre-feet of water for navigation as far as the Sheksna River. Below the Sheksna, the Volga flows southeast along a broad valley, consisting of wide former lakebeds. It receives many tributaries throughout its course. From the north, the Unzha, 365 miles long; the Oka from the southwest, 950 miles long, rises in Orel near the sources of tributaries of the Don and Dnieper. The Oka and Volga join near Gor'kiy, below which the Volga enters a board depression at an elevation of 190 feet, with channel widths of 1,000 feet to 1 mile. Islands appear and disappear after the spring floods. The Volga receives the Kama from the east below Kazan, and makes a large bend at Kuybyshev to avoid the Zheguli extension of the Russian Plateau. At Kuybyshev the Volga is 54 feet above sea level. At Stalingrad, the Volga is only 45 miles from the Don River, below which the rivers flows sharply to the southeast through low Caspian steppes. Near Stalingrad the Volga sends off a branch, the Akhtuba, which accompanies it to the sea for 350 miles. Low hills skirt the right bank, but on the left bank it joins with the Akhtuba to frequently flood the country for 15 to 35 miles. The delta begins 40 miles above Astrakhan and contains as many as 200 mouths. The Volga erodes its banks and washes away fertile alluvial soil, depositing large volumes in the Caspian Sea, the level of which rises during the Volga floods. The Kama River is the major tributary of the Volga, rising in the Urals, with a length of 1,200 miles, and an annual discharge of 140,000 cubic feet per second.

About 2,000 miles of the main stream from Astrakhan to north of Moscow, and 1,000 miles of tributaries have navigable depths in excess of 10 feet and over 4,000 miles of the main stream and tributaries have navigable depths of from 3 to 10 feet. The Volga is connected with the Moscow area by a 75-mile canal, which has large locks 100 by 1,000 feet with 18-feet depth over the sills. A 300-mile canal, the Mariinskiy Canal, with small and antiquated locks, now connects the Volga system near Moscow, via Lake Onega, with the more modern Stalin Canal system which joins the Baltic and White Seas. Access to the Black Sea is provided by the Volga-Don Canal with modern locks capable of handling most large river craft. The 45-mile Severo-Dvinsk Canal links the Volga-Baltic route to the Northern Dvina River and the White Sea at Archangel. Its locks will not accommodate the largest vessels.

The upper Volga and tributaries have rapids and shallows in certain areas and are used chiefly for log rafting and floating. Depths on the Moskva and upper Oka Rivers are increased by several old dams and locks.

From Astrakhan to the Caspian, a 71-mile stretch of nontidal estuary is very difficult for navigation, where continuous dredging is necessary to insure adequate navigable depths. The present difficulties to navigation on the Volga River and tributaries are the ice, the freezes lasting from 90 to 160 days when the streams become sled routes, and the shallows during the late summer.

On the Volga and Kama Rivers, a series of 12 multiple-purpose projects have been or are proposed for construction, with a total capacity of 12 million kw, and an annual production of 65 billion kwh. Six are in operation, three are under construction, and three are being planned. The proposed dams and accompanying navigation locks will provide a 10-foot or deeper channel over 2,000 miles of the main stream, and 1,000 miles of the tributaries. The completed and proposed projects in the Volga River Basin are as follows:

Stream	Project	Capacity (thousand kw)	Status
Upper Volga	Ivankovo	30,000	Operation 1937.
	Uglich	220,000	Operation 1941.
	Rybinsk	330,000	Do.
	Gor'kiy	400,000	Operation 1956.
Kama	Cheboksary	1,000,000	Planning.
	Kama (Perm)	504,000	Operation 1957.
	Votkinsk	1,000,000	Under construction.
	Lower Kama	1,400,000	Planning.
Lower Volga	Kuybyshev	2,300,000	Operation 1957.
	Saratov	1,000,000	Under construction.
	Stalingrad	2,530,000	Operation 1960.
	Lower Volga	1,000,000	Planning.

The Gor'kiy Dam is located on the Volga River about 40 miles upstream from Gor'kiy. It consists of a dam 8 miles long, and two sets of parallel locks, 100 by 1,000 feet, with an intermediate reservoir between the upper and lower locks 2 miles long for boat repairs, and a canal to the river. The reservoir is 290 miles long, and required the construction of 75 miles of levees and dikes to protect towns and villages in the reservoir area. The power installation consists of eight 50,000 kw units, which operating on a head of 55 feet will produce 1.5 billion kwh annually. The reservoir provides navigation 300 miles upstream and in the lower reaches of several tributaries, improves the water supply for the cities downstream, and assists in providing flood control in the basin. The project was placed in operation in 1955 and 1956.

The Kuybyshev Dam and Reservoir is located near Zheguli on the Volga River 30 miles above Kuybyshev. The dam is about 3.5 miles long with a reservoir 400 miles long, covering an area of 1,500,000 acres. The power installation consists of 20 units of 115,000 kw each, a total of 2.3 million kw, presently the largest hydroelectric project in the world. The powerplant will produce 12 billion kwh of energy on a head of 62 feet annually. The first unit was placed in operation in 1955, 11 more in 1956, and the remainder in 1957. The reservoir clearing required the relocation of 150,000 persons. Another powerhouse is being planned, at which time fish ladders may be installed. Storage in the Kuybyshev Reservoir is needed to permit economical use of the water resources. Gated openings are placed on each side of the powerhouse to pass floodwaters downstream. Trash racks are located in front of and independent of the powerhouse to prevent loss of head. The reservoir is operated for flood control and flow regulation and permits navigation upstream through the reservoir area.

The Stalingrad project is located on the Volga River immediately above Stalingrad. It consists of a dam 3 miles long with two parallel sets of double-lift locks 100 by 1,000 feet, and a 3-mile canal to the river, a fish elevator, and two railroads and one 36-foot roadway across the dam. The reservoir is 370 miles long and covers 742,000 acres. The power project consists of 22 units of 115,000 kw each, a total of 2,530,000 kw, which will operate on a maximum head of 85 feet, and produce 12 to 15 billion kwh of energy annually. Three units were placed in operation in 1958, six more are planned for operation in 1959, and the remainder by 1961. The reservoir will furnish power to the Moscow area and to industrial areas in the Urals, provide flow regulation to downstream projects, provide storage for the irrigation of about 2.5 million acres of land in the lower Volga River Basin, and will be a unit in the chain of development of a navigable route from the Caspian and Black Seas to the White and Baltic Seas.

PECHORA RIVER

The Pechora River rises in the Ural Mountains, flows west and then north with a double north and south loop. It is 1,150 miles long and enters the Gulf of Pechora on the Barents Sea through a delta. Its main tributaries are the Izhma, Tsil'ma, and Sula on the left bank, and the Ilych, Podcherem, Shugor, and Lisa on the right. The river and its tributaries provide 3,545 miles of navigable waterways, of which 580 miles of the main stem and the Usa have depths in excess of 10 feet, and about 1,000 miles of the main stem and tributaries have depths of from 3 to 10 feet and are usable for steamer transportation. The remainder is usable for rafts and timber floats. The Pechora River serves the Vorkuta coal-mining area. During the brief summer there is steamer connection between Pustozersk and Kuya on the right of the delta and Archangel. Short portages connect the Pechora waterway with the Kama and the Volga, and with Vychegda and Northern Dvina, and longer portages link it across the Urals with the Ob. The chief traffic consists of furs, fish, and reindeer products moving south, and grain and manufactured products moving north. Timber products move in both directions and form the major bulk commerce. Seals are caught in the Pechora Gulf and the Pechora salmon are especially valuable. Plans have been proposed for diverting flows from the upper reaches of the Pechora River into the Volga River Basin to increase navigation and power production, and to compensate for evaporation losses from the large reservoirs and withdrawals for irrigation.

MEZEN' RIVER

The Mezen' River rises in a swampy area between the tributaries of the Pechora and the Northern Dvina and flows about 400 miles north to enter the Mezen Gulf, an arm of the White Sea north of the city of Mezen. The main stream has navigable depths in excess of 10 feet for about 25 miles above its mouth, and over 800 miles of the upper main stream and tributaries have depths of from 3 to 10 feet. The main stream and tributaries flow through a largely undeveloped area, and are used chiefly for rafting and floating of logs.

NORTHERN DVINA RIVER

The Northern Dvina River is formed by the junction of the Sukhona and the Yug near Velikiy-Ustyug at an elevation of 300 feet. The drainage area is 141,000 square miles. The Sukhona is 780 miles long, and the distance from its mouth to the Gulf of Archangel near the city of that name, an arm of the White Sea, is 470 miles. Except at a few rapids the current is slow. Above the junction of the Vychegda at Kotlas the Northern Dvina flows in a single, well defined, and permanent channel, but below that point it often splits into several channels and frequently alters its course. Near Archangel it splits into three arms which form a delta, with the Berezov Arm navigable for seagoing vessels. Just above the delta the Pinega enters from the right bank. Above the junction of the Vychegda the width of the channel is about 1,750 feet, below that point it widens to about 3,500 feet, and near Archangel the width is about 1 mile.

About 400 miles of the main stream from its mouth to Kotlas has navigable depths in excess of 10 feet. About 2,700 miles of the main stream and its tributaries have navigable depths varying from 3 to 10 feet. The 45-mile Severo-Dvinsk Canal connects the Northern Dvina River with the Volga River, providing access from the White Sea at Archangel to the Volga-Baltic navigation route and to the Volga River system. Its locks cannot accommodate the largest river craft. The Northern Dvina was once linked to the Kuloy River to the northeast by a canal which is no longer in use. The channel of the Northern Dvina is free from ice for about 175 days of the year.

ONEGA RIVER

Onega River rises in Lake Vozke and flows about 300 miles north to the Gulf of Onega, an inlet of the White Sea. The stream is navigable about 250 miles to Kargopol' on Lake Lacha. Depths vary from 3 to 10 feet, and the stream is used primarily by smaller craft and rafts. A large lumber industry is located at Onega near the mouth of the stream. Steamer routes extend from Onega to Soroka, Kem', and Archangel, although the navigation season is short.

VOLGA-BALTIC ROUTE

The Volga-Baltic navigation consists of three sections. The 100-mile section of the Sheksna River; 150-mile Mariinskiy Canal; and 100 miles of the Stalin Canal connecting the Baltic and White Seas. These routes go through Lakes Onega and Ladoga and the Neva River. The total route is about 360 miles.

Lake Onega is 145 miles long with an area of 3,820 square miles, next to Lake Ladoga, is the largest lake in Europe. It has an elevation of 125 feet, and depths of 120 to 400 feet. Affluents, the Vodla, Andoma, and Vytegra enter from the east. Onega Canal, 45 miles long, along the southern shore connects the Svir River and Lake Ladoga with the Baltic and with the Vytegra and the Mariinskiy Canal, which connects with the Volga River system. The locks in the southern portion of the connection, those on the Sheksna River, are capable of handling medium-sized river craft, while those of the Mariinskiy Canal in the northern portion can only accommodate

small river craft. The Onega Canal offers a protected passage for the small river craft usable on other sections of the route. The 45-mile Severo-Dvinsk Canal links the Volga-Baltic route with the Northern Dvina River system, connecting to the White Sea at Archangel. The locks in this canal are slightly larger than those of the Mariinskiy Canal section of the Volga-Baltic route. Lake Onega is free of ice about 210 days.

Construction of four large dams and other work is proposed on the Onega Canal and in the vicinity of Lake Beloye, and modernization of other navigation structures is proposed for the near future so that by 1963, the connection to the Baltic will have the same navigable capacity as the Stalin Canal and the Volga-Don Canal. This will provide depths in excess of 10 feet over the entire 360 miles of the route, and greater depths than are available at present on about 100 miles of tributaries in the area. It will provide a protected navigation route from the Baltic and White Seas to the Caspian and Black Seas.

BALTIC-WHITE SEA ROUTE

The Baltic-White Sea route has a total length of 640 miles extending from the Baltic at Leningrad through Lake Ladoga, the Svir River connecting that lake with Lake Onega, through Lake Onega, and through the Stalin Canal extending from the northern portion of Lake Onega to the White Sea. Two dams on the Svir River provide adequate depths for navigation over that section of the route.

The Neva River has a length of 40 miles, flows from the southwest corner of Lake Ladoga and carries off into the Gulf of Finland the waters of Lakes Ladoga, Onega, Il'men', and many smaller basins. One channel from Lake Ladoga has a depth of from 7 to 16 feet. About 10 miles above its outfall, the Neva reaches Leningrad and divides into the Great Neva, the Little Neva, the Great Nevka and the Little Nevka. The city of Leningrad is located on islands in the delta of the Neva. In front of the delta are rocks and sandbanks which prevent the passage of vessels except by a canal 18 miles long and 100 to 250 feet wide, which admit deep-draft vessels from Kronstadt to Leningrad. When Lake Ladoga sends down its vast accumulations of block ice, dangerous inundations occur at Leningrad. The Neva freezes the latter part of November and remains so until about mid-April.

Navigable depths of over 10 feet are available over the entire 640 miles of the route from the Baltic to the White sea near Belomorsk, and depths of from 3 to 10 feet are available over about 500 miles of tributaries and adjacent canals. The canal along the southern shore of Lake Ladoga provides a protected route for passage of small river craft, unsuited for wave conditions frequently encountered on the lake. The 135-mile Stalin Canal links Lake Onega with the White Sea and forms the northern portion of the route. The locks are constructed of wood but are modern structures and can handle large river craft. When the reconstruction of the Lake Onega-Moscow connection is completed, the Soviet Union will have an inland waterway system linking the Black, the Caspian, and the Baltic Seas, and the Arctic Ocean, and capable of providing passage for river craft, smaller types of seagoing vessels, and submarines.

WESTERN DVINA

The Zapatnaya or Western Dvina rises in a small lake near the sources of the Volga and the Dnieper, flows 640 miles through Latvia to the southern end of the Gulf of Riga, an arm of the Baltic Sea. The drainage area is 32,960 square miles. In its lower reaches it has a depth of 30 feet and an average width of 1,400 feet, but during the spring flood the water level rises about 15 feet and spreads out a mile in width. Near the mouth the river is usually ice-free for 245 days of the year. The river is navigable below the confluence of the Mezka at Vitebsk, but rapids and shallows diminish its usefulness. Navigation is also carried on on several of its tributaries. The stream is an outlet for timber from the west of Russia. A multiple-purpose project on its tributary the Dangara has been considered.

NEMAN RIVER

The Neman River, known as the Memel in its lower section, rises in White Russia near Minsk, flows south, west, then north and west, about 350 miles to enter the Baltic Sea at Memel. The harbor at Memel has a depth of about 26 feet. Over 500 miles of the main stream and tributaries and adjacent waterways have navigable depths of from 3 to 10 feet. Icebreakers keep the harbor at the mouth open from December to March. Timber, grain, fish, and agricultural products comprise the traffic moved over the waterways. The Neman was formerly connected by canals with the Pregel River, and with the Polish Vistula River system and to the Dnieper River waterways, but these canals are no longer in use. A dam is under construction on the Neman River at Kaunas, and seven other dams are proposed. Completion of these projects will increase navigable depths to 10 feet or more for distance in excess of 500 miles on the main stream and tributaries.

MINOR STREAMS

The Terek River rises in the glaciers on Mount Kasbek on the northern slopes of the Caucasian Range and flows through a series of gorges before it emerges on the plains to the north, where it collects the waters of numerous tributaries. It flows through the steppe country to the Caspian Sea, entering that sea in its central section on the west bank. Most of the water of the Terek is lost by evaporation and irrigation, yet it has built a large delta stretching for 70 miles along the coast, with branches shifting in flood time and changing their relative importance. The Terek River was once navigable. In its lower course it flows above the level of the surrounding country. Among the more important irrigation canals are the Eristovka and Kurskiy, fed from the Malki River, and recently a large part of the Nogai Steppe has been placed under irrigation.

The Ural River rises on the eastern slope of the Ural Mountains, near the source of the Tobol River, a tributary of the Ob. It flows south then west around the south end of the Urals, thence south to enter the northern end of the Caspian Sea east of the mouth of the Volga. The length of the Ural River is about 1,000 miles. Former tributaries of the Ural on both the right and left banks now lose

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themselves in the desert. The stream is frozen from November to mid-March at Guryev, and further north until mid-April. The stream was once navigable. It floods its banks in the spring but is shallow most of the year. The delta had 19 branches in 1769, 9 in 1821, and only 3 now, except in the spring when there is a considerable swampy area in the lower reaches. Projects proposed in the upper reaches will develop power for industry, provide flood protection, and furnish water for irrigation. The principal cultivation along the stream is in the northern valley from Ural'sk to Magnitogorsk, which adjoins the Kustani district of the Tobol and the Ishim, tributaries of the Ob.

The Emba River flows from the Mugodzhar Hills westward to reach the Caspian Sea in its northern section by a series of rapidly drying shallow lagoons which were navigable as late as the 18th century. Shifting sands fill the tributaries and lakes, although some of the area is irrigated in small tracts and some of the old irrigation projects are being restored.

The Aral Sea is the fourth largest inland sea in the world. It is about 130 by 280 miles, with an area of 24,600 square miles, a depth of 223 feet, and an elevation of 174 feet, 266 feet above the Caspian Sea. It is bounded by steppes on the north, the rocky plateau of Ust'-Urt on the west, the alluvial district of Khiva on the south, and the Red Sand Desert district on the east. Frequent violent storms on the Aral Sea hinder navigation as no shelter is afforded to ships. The sea is navigated by flat-bottomed boats. Its shores are not thickly populated. Fishing in the area is an important industry, with fresh-water species abounding.

The Amu Darya River rises in the mountainous plateau forming the boundary between the Soviet Union and Afghanistan and flows northwesterly about 900 miles to enter the southern end of the Aral Sea. The river brings down vast quantities of sediment, and the delta, about 80 by 10 miles, is increasing. About 1,070 miles of the main stream and the Aral Sea, from Termez to Mukus, and extending into the sea, has depths in excess of 10 feet; 180 miles of the main stream and tributaries has depths of from 3 to 10 feet. Completed reservoirs on the tributaries increase and regulate flows on the main stream. No improvements have been made for navigation, as its importance has declined since completion of a railroad parallel to the river in its upper reaches. Shallows at the mouth and in the delta prevent the larger lake vessels from entering into the river. Withdrawals of water for irrigation are increasing as new areas are placed under irrigation.

The Syr-Dar'ya rising in Kirgizh State flows about 1,200 miles northwesterly to enter the Aral Sea near its northern end. The stream does not have a large delta such as the Amu Darya and as it flows through an arid and desert area, navigation does not extend far upstream. In its upper reaches, large areas above and below Taskent are under irrigation and the area is increasing. The Taskent and Uzbek area is located in a loess oasis, watered by the Chirchik and Keles tributaries of the Syr Darya. Irrigation is very ancient in this area. Cotton, tobacco, fruit, melons, rice, nuts, and agricultural products are grown in the area.

East of Tashkent, Alma Ata is located on the northern slopes of the Khungai Ala Tau Mountains in an area watered by streams which run through the loess area below to Lake Balkash. The climate and

soil are favorable to vine and fruit cultivation, and large areas are under irrigation. There is an ample water supply in the mountains of this south central section of Russia, and multiple-purpose projects for development of hydroelectric power, flood control, and irrigation will contribute materially to the economic resources of this section of the Soviet Union.

KHRAMI RIVER

The Khrami River rises in Lakes Paravani and Sagamo, high in the Caucasian Mountains about 40 miles southwest of Tbilisi, in the Republic of Georgia. The stream is 150 miles long and is a tributary of the Kura River, which flows into the Caspian Sea. Lake Paravani has an area of 54 square kilometers and a capacity of 300 million cubic meters. It is proposed to completely develop the cascade and the power potential of the Khrami River by the construction of six projects having a total capacity of 700,000 kilowatts and an annual power output of 2 billion kilowatt-hours. The average annual runoff of the Khrami River at the upper project is 308 million cubic meters.

The first project, Khrami No. 1, was placed in operation in 1947 and completed in 1949. It consists of a rockfill dam, 3,465 feet long and 108 feet high at the entrance to a narrow gorge of the Khrami River, which creates a head of 1,380 feet by use of a 4.6-mile pressure tunnel to the powerplant several miles downstream from the dam. The upstream slope of the dam is covered by a stainless steel shield laid on top of a concrete lining to prevent seepage of water into the dam. The reservoir has a capacity of 312 million cubic meters and a surface area of 34 square kilometers. The installed capacity of the powerplant is 112,800 kilowatts from three units.

The second station of the cascade, Khrami No. 2, is now under construction and is expected to begin delivery of power in early 1961. It consists of a diversion dam and intake on the Khrami River immediately below the powerplant of No. 1, and a concrete-lined tunnel 12 feet in diameter and 8 miles long to a powerplant on the river downstream therefrom. The powerplant will have a capacity of 250,000 kilowatts. Pressure tunnels totaling 6 miles from three other tributaries of the Khrami River will supplement the main tunnel.

Khrami No. 3 is now being planned and will be initiated within the present 7-year plan, and will be the upper station of the entire power development. It will consist of a diversion tunnel to convey the discharge of Paravani and Sagamo Lakes into the reservoir of Khrami No. 1, raising the level of Lake Paravani by 25 feet. At the end of this diversion tunnel the Nardevani powerplant will be constructed with a generating capacity of 140,000 kilowatts and a head of about 1,650 feet. Three smaller projects are proposed on the river below Khrami No. 2 which will bring to full utilization the total head of the cascade, 4,500 feet.

OB RIVER

The Ob River, the second largest river in the U.S.S.R., rises in the Altai Mountains, courses about 3,200 miles through hilly country to the Kirghiz Steppe, and through the plains area and the tundra to its delta in the Gulf of Ob, an inlet of the Arctic Ocean 600 miles in length. The area of the basin is considerably more than a million

square miles, and the average flow of the Ob River is 450,000 cubic feet per second. In the central section south of the junction with the Irtysh and extending between the two streams are the Vasyugan Swamps, which cover about 100,000 square miles, so named from the Vasyugan River, a left bank tributary of the Ob. The swamps are frozen and can be crossed in winter, are flooded in the spring, and become impassable marshes in the summer. When drained the land becomes fertile. The Irtysh River is the largest tributary of the Ob and the fifth longest river in the Soviet Union, entering the Ob on the left bank. The Irtysh rises in China and flows through the Dzungarian Gate into Russia, where it expands into Lake Zaisan, and then cuts its way across a spur of the Altai Mountains onto the plains. Its total length is 2,700 miles and its average annual flow is 210,000 cubic feet per second. The fall of the river from Lake Zaisan to Omsk is 1,000 feet in about 1,000 miles.

The navigable waters in the Ob Basin total more than 10,000 miles. Below the confluence of the Irtysh, the Ob divides into more than one arm and is of little use for navigation except for barges bringing fish from the delta in the autumn. Above the junction of the Irtysh, steamers and barges ply upon the Ob and its tributaries, the Irtysh, Tobol, Tavda, and the Tura, during the summer and fall. Several hundred steamers and barges use these navigable streams. The east-west river traffic is giving way to railway communication, but the north-south route is still very important. The river is frozen from November to May or June, and floods, ice, and floating timber impede navigation for some time after the thaw.

Approximately 1,700 miles of the main stream of the Ob from its mouth to the confluence of the Ket and from Novosibirsk to Kamen' are navigable to depths in excess of 10 feet, and 450 miles of the Irtysh River from its mouth to Tobol'sk and above Ust'-Kamenogorsk is also navigable to similar depths. About 8,000 miles of the main stream and tributaries, including numerous channels north of the confluence of the Irtysh River, have depths varying from 3 to 10 feet. The main stream below Novosibirsk has ample depth and width for present needs of commerce, as it flows through sparsely settled taiga and tundra regions, and traffic is not extensive. The canal system which formerly connected the Ob and Yenisey Rivers is no longer in use. The Irtysh River serves a rapidly developing agricultural and industrial region.

It is planned to build nine hydroelectric powerplants on the Ob River with a total capacity of 12 million kilowatts, and an annual production of about 50 billion kilowatt-hours. One plant on the Ob River near its mouth would have an installed capacity of 6 million kilowatts. A project at Novosibirsk on the Ob River south (upstream) from the city is complete and in operation. It has an installed capacity of 400,000 kilowatts and an annual production of 1.68 billion kilowatt-hours. The dam is about 3 miles long and 75 feet high. The reservoir extends 130 miles upstream to the vicinity of Kamen, and has an area of 325,000 acres. The dam contains navigational locks to permit extension of navigation upstream through the reservoir. Construction of a second plant on the Ob River in the vicinity of Kamen at the upper end of the Novosibirsk Reservoir is to start by 1965. The Kamen Reservoir will permit extension of navi-

gation about 250 miles upstream beyond the end of the railroad spur at Biysk. Completion of the proposed projects on the Ob River will provide depths in excess of 10 feet over a total length of 2,000 miles of the main stream and up many of the tributaries. The Novosibirsk project provides flood control for the industrial city and adjacent region and an adequate water supply for commercial and industrial uses.

The proposed multiple-purpose plan of development for the Irtysh includes a total of 16 projects for development of hydroelectric power, improvement of navigation, irrigation, flood control, and water supply for industrial uses. The projects are proposed to include a power installation of 4.5 million kilowatts and an annual production of about 19 billion kilowatt-hours. One project at Ust-Kamenogorsk on the Irtysh River about 7 miles above the city of that name is complete. The dam is 1,400 feet long and the reservoir extends upstream about 50 miles. It has a power installation of about 400,000 kilowatts, operating on a head of 132 feet, and producing 1.5 billion kilowatt-hours of energy annually. The navigation lock with a lift of 130 feet is the highest single-lift lock in the world.

The Ust' Bukhtarma project is under construction on the Irtysh River below the confluence of the Bukhtarma River, about 58 miles upstream from Ust' Kamenogorsk. The project is planned for completion in 1961. It will have a dam 297 feet high and a power installation of 540,000 kilowatts, producing 2.5 billion kilowatt-hours annually. The reservoir will extend upstream about 370 miles. Four-lift navigation locks are proposed, which will permit extension of navigation to Lake Zaisan and to the Chinese border. Completion of the projects proposed for the Irtysh cascade will provide navigable depths in excess of 10 feet over about 2,300 miles of the Irtysh River and up many of its tributaries; provide flood control; permit irrigation of many thousands of acres; and provide an ample water supply for a growing industrial area.

YENISEY RIVER

The Yenisey River, the largest river in the Soviet Union, is formed by the junction of the Bel-kem and Chua-Kem in the mountains west of Lake Baikal. From its source the stream flows north about 3,500 miles into the Arctic Ocean. It has a drainage area of over a million square miles, and an average flow of about 600,000 cubic feet per second. Through the prairie region the Abakan River enters from the left bank and the Tuba from the right. The railroad crosses the Yenisey at Krasnoyarsk. The Angara, or Upper Tunguska, joins the Yenisey after flowing about 1,200 miles from Lake Baikal and south of the Pit Mountains. The Stony Tunguska, 1,000 miles long, enters the Yenisey on the right bank downstream from the Pit Mountains, flowing through a marshy largely uninhabited country. The Lower Tunguska is about 2,000 miles long, enters the Yenisey from the right bank and extends eastward almost to the Lena River. The Turukhan and Kureika Rivers enter from the left bank in the lower reaches. The Yenisey enters the Yenisev Gulf, which is about 40 miles wide and 300 miles long, through a delta about 6 miles wide. The west bank is low and marshy and the east bank steep.

Navigation on the Yenisey is less important than on the Ob, due to the scanty population and more difficult environment. Oceangoing vessels can ascend the Yenisey for about 450 miles from the Arctic Ocean to Igarka, and navigable depths in excess of 10 feet are available to the mouth of the Angara River, about 1,350 miles, and on over 600 miles of tributaries, including Lake Baikal. About 3,500 miles of tributaries and the main stream have navigable depths varying from 3 to 10 feet. Gol'chikha on the delta and Yeniseisk have steamer communication with Krasnoyarsk and Minusinsk. Formidable rapids above the latter point limit raft navigation.

In its central regions the Yenisey is about a mile wide and frozen from December to May. At the delta the river is normally frozen from late October to June. The frozen river serves as a good road. Floods in May and June collect huge blocks of ice after the thaws in May or June. Above the confluence of the Stony Tunguska, the Yenisey is wide and reefs of rocks known as the "Seventy Islands" rise above its waters. An old canal system fomerly linked the Kaz, tributary of the Yenisey, with the Ket, tributary of the Ob, but it is no longer in use.

A scheme for the construction of 20 hydroelectric powerplants with a total capacity of 20 million kilowatts and an annual production of over 100 billion kilowatt-hours on the Yenisey River and tributaries is being studied. The Krasnoyarsk project on the Yenisey about 22 miles above that city is now under construction. The dam will be 330 feet high and the reservoir will extend 250 miles upstream, with a maximum width of 55 miles and a volume of about 50 million acre-feet. The powerplant will have an installation of 10 units having a capacity of 500,000 kilowatts each, a total capacity of 5 million kilowatts, having an estimated power output of 20 billion kilowatt-hours annually. The powerhouse is being constructed with space for two additional generating units. The project planned for the main stream below the Angara River has a proposed capacity of 6 million kilowatts.

The completion of Krasnoyarsk Dam will increase depths for navigation about 300 miles upstream. Completion of other proposed projects on the main stream will provide over 1,800 miles of navigable waterway for the largest river steamers. At the present time ship locks are not considered economical in the dams because of the relatively small amount of commerce, which will be transshipped by rail. A ship elevator instead of a lock is planned for installation in the Krasnoyarsk Dam after 1965, and in the later projects when needed.

Completion of the proposed projects on the Yenisey River will provide complete control of floods and further improve navigation conditions on the main stream and tributaries by providing regulated flows, greater depths in the reservoirs, and better control of ice flows and jams.

ANGARA RIVER

The Angara River flows 1,200 miles north out of Lake Baikal to its confluence with the Yenisey, and is the most important tributary of that stream. Lake Baikal acts as a regulating reservoir for the Angara River, as there are 336 streams flowing into the lake and only the Angara River flowing out. The area of the lake is 31,500 square kilometers and it is over a mile deep. The average flow of the Angara

River is 150,000 cubic feet per second, and the total cascade of the stream is 1,180 feet.

Navigation on the Angara River is limited to 10- to 12-foot depths for a short distance above its confluence with the Yenisey; to a section from Irkutsk to the vicinity of Bratsk, where the Padun Narrows and shoals in the river form a barrier to navigation; and to the river and lake above the Irkutsk Dam.

Six projects have been projected for the main stem of the Angara River, with a proposed capacity of 14 million kilowatts and an annual production of over 70 billion kilowatt-hours. The Irkutsk project located on the Angara River 2.5 miles upstream from Irkutsk was placed in full operation in 1958. The dam is 1.5 miles long and 135 feet high, and the reservoir extends 40 miles upstream to Lake Baikal, with an area of 5,600 square kilometers. The power installation consists of eight units of 82,500 kilowatts, which operating on a head of 79 feet will produce about 4.5 billion kilowatt-hours of energy annually. The Irkutsk Dam raises the level of Lake Baikal about 4 feet, and maintains control of the lake as needed for the Bratsk and downstream projects. The dam has no spillway but has 16 controlled openings through the powerhouse for passing floodflows and flows for downstream regulation to develop maximum potential of projects.

The Bratsk hydroelectric project is under construction on the Angara River 22 miles downstream from Bratsk. It is located in a canyon on the Angara River about 2,600 feet wide with vertical walls 250 feet high. The dam will have a total length of 3.2 miles, including the concrete canyon section of spillway and powerhouse, and earth wing dams. The reservoir will extend upstream about 350 miles and inundate about 1,360,000 acres. The powerplant will have an installation of twenty 225,000-kilowatt generating units, a total of 4.5 million kilowatts, and will have an average output of 22 billion kilowatt-hours annually. Due to the storage in the Bratsk Reservoir, and the regulation in the Irkutsk Reservoir and Lake Baikal, the annual production will have only a slight variation.

The Irkutsk Dam has increased the depths in the mouths of the tributaries into Lake Baikal and of the outlet from the lake into the Angara River, thus facilitating passage by large lake streamers previously unable to pass through shallows at river mouths and through the outlet. A future lock and canal on the left bank of the river at the Irkutsk Dam is proposed to provide navigation from Lake Baikal down the Angara River when required by river traffic. Likewise, navigational facilities will be constructed at the Bratsk Dam, and other projects on the Angara River, when considered economically feasible and necessary for accommodation of river commerce. New harbors and dock facilities will be constructed on the reservoirs after completion of other projects in the Angara cascade. Such completion will convert the Angara River into a series of slack water pools which could accommodate the largest river vessels, and connect that stream into the Yenisey River system of about 6,000 miles of navigable waterways. The Irkutsk Reservoir has eliminated the flood problem that formerly existed at the city of Irkutsk; has provided a water supply for Irkutsk and industries located in the region; has permitted recreational development on the arms and bays of the reservoir; and has improved fish development in the area.

LENA RIVER

The Lena River flows from the western slopes of the Baikal Mountains northward to the Arctic Ocean. It has a length of about 3,000 miles and a drainage area in excess of 1 million square miles, with several hundred tributaries. It is a mountain stream from its source until joined by the Vitim River on its right bank, which rises about 80 miles east of Lake Baikal at an elevation of about 6,000 feet, flows about 1,200 miles to join the Lena at Vitim, elevation 670 feet. The Lena then flows through thickly wooded plains, the Siberian "taiga," to its right bank tributary, the Olekma, near Olekminsk at elevation 375, which is about 900 miles long and whose strong current affects the Lena for some distance below the confluence. Further downstream the Botama joins the Lena on the right bank near Lena Stolbi, columns of perpendicular limestone cliffs rising about 2,000 feet in some places. Immediately downstream is Yakutsk, a nodal trading point where the river widens. A hundred miles below Yakutsk the Lena is joined by the Aldan River on the right bank which is 1,500 miles long. The headwaters of this stream rise near those of the Zeya and Olekma, on the Aldan Plateau, and its eastern branches are but 40 to 50 miles from the Sea of Okhotsk, of which the tributaries, the Urchur is 350 miles in length, the Amga 800 miles, and the Maya 400 miles. Below the mouth of the Aldan, the Lena flows for about 900 miles with an average slope of about 2 inches per mile with widths varying from 4 to 20 miles, and with sandy banks and unstable alluvial islands in its course. In this section it is joined on the left bank by the Vilui River, which flows for about 1,500 miles to its delta with the Lena. From Bulun to the delta, the Lena flows between the Khara-Ulakh Mountains on the east and the Lower Chekandvst Mountains on the west.

The Lena River is navigable to depths in excess of 10 feet from its mouth to the mouth of the Aldan River, and with lesser depths to above the mouth of the Vitim. Of its tributaries, the Aldan is navigable for depths of from 4 to 10 feet for 800 miles, the Vilui for about 900 miles to the same depths, and other tributaries for shorter distances. The total length of navigable channels in the Lena Basin exceeds 4,000 miles.

The Lena River discharges into a delta which begins 100 miles inland and is 250 miles wide on the coastline. This delta is a vast sandbank intersected in every direction by numerous channels which change direction from year to year and render navigation difficult. As the ice breaks up in the upper reaches huge ice blocks are carried down by the floods and piled up on the delta, still frozen to a depth of several feet. These blocks of ice erode the banks and alter the navigation channels. The delta ice begins to break up in early July and freezes about the middle of October. The navigation season at Yakutsk is from early June to October. Commerce on the Lena and its tributaries is about 30,000 tons annually.

The Lena River is not as large as the Yenisey, and is the most easterly important stream in northern Siberia, although the northern portion of the basin is sparsely settled. Other northerly flowing streams east of the Lena, the Yana, Indigirka, and the Kolyna, flow through regions very sparsely populated. The Lena River is now being studied for possible development, and one small project on a tributary of the Vitim is under construction.

AMUR RIVER

The Amur River is the chief river of eastern Asia north of the Yellow River, with a length of about 3,000 miles. It is formed by the confluence of the Shilka River, rising in Transbaikalia, and the Argun River, rising on the back slope of the Great Khingan in Mongolia. Its major tributaries, the Sungari, and the Ussuri, enter from the south. The boundary between Siberia and Manchuria follows the line of the Argun, Amur, and Ussuri, thus forming one of the longest international river frontiers in the world. The river reaches its highest stages in summer, the season of rains and melting snow, and is frozen in winter. The maximum rainfall is in July and August.

Navigation is confined to the 6-month period from May to October. The mainstream is navigable for vessels drawing 10 feet of water for about 630 miles from its mouth to Khabarovsk. For vessels drawing from 3 to 10 feet, the Amur and its tributaries are navigable almost 3,000 miles to Stretenskoye on the Shilka, to Hungki (Kirin) on the Sungari, and on the Zeya and Bureya Rivers. These streams furnish boat communication in summer and sled communication in winter. The Sungari River is the most important waterway in Manchuria, connecting the rich agricultural areas with the railheads.

A broad fertile plain extends from the junction of the Zeya with the Amur at Blagoveschensk to Bureya, 250 miles downstream. Above Blagoveschensk the river valley is narrow and there is little land available for cultivation. The river is broad and the current is slow at Blagoveschensk, 1,200 miles above its mouth, at which point the elevation is less than 400 feet.

The fact that the outlet of the Amur River lies so far north deprives it of much of its value for navigation, and the Chinese Eastern Railroad is connected with the more southerly ports around Vladivostok and in Manchuria. The area has developed markedly since construction of the Trans-Siberian Railroad through the area, with its branches to many of the nearby industrial centers.

Planning and construction work on the Amur River is complicated by such a large section being an international stream, and the fact that the Chinese give highest priority to flood control, while development of hydroelectric power is given highest priority by the Soviet Union. A scheme for development of the Amur River has been under consideration for several years. Data on hydrology of this region are said to be meager. One multiple-purpose project for flood control and power with an installation of 800,000 kilowatts is under construction on the Zeya River, and a similar project on the Sungari River 20 miles south of Kirin has an installation of 495,000 kilowatts. Six dams are being planned as joint projects on the international section of the Amur with a total hydroelectric power installation in excess of 6 million kilowatts, and initiation of construction of one of these joint projects is planned by 1962. In addition, numerous projects on tributaries of the Amur in the U.S.S.R. and China are under consideration. Studies have been made of a cutoff navigation channel to bypass the Amur River Delta and provide a shorter route to the sea.

CONSTRUCTION METHODS

The American delegation was impressed with the methods of construction of projects in the Soviet Union. This was particularly true with respect to two important economical features: (*a*) construction of earthfill dams by hydraulic methods, and (*b*) the use of precast concrete sections and forms in construction of locks, dams, and powerplants.

Most of the major projects on streams in the Soviet Union are well adaptable for construction by hydraulic fill. The streams are alluvial and adequate borrow material is available at the construction site. The streams are navigable and dredges can be floated to the site with a minimum of mobilization and demobilization costs. Large numbers of cutter-head dredges are assigned to each project. These dredges work in depths up to 40 meters where the borrow pits are under water and can be utilized only with dredges. Each dredge will place about 1,000 cubic meters of material per hour, and it was stated that all the dredges on the Kuybyshev project moved about 300,000 cubic meters per day.

In the design of the earthfill sections of the dams, measures are taken to spread the sections of the dam to lengthen the path of percolation through the previous foundation and spread such percolation evenly over the entire base. Sheet pile or other cutoff walls under the base may extend 20 or 30 meters below the surface of the foundation, but do not extend to bedrock or clay, which is frequently as much as 70 meters deep. Certain cross sections of the earthfill sections appeared to be two or three times the width normally used in the design of earthfill dams in the United States. Caissons and sheet piles are individually jetted into the sand rather than driven. A downstream toe-trench drain consisting of a perforated pipe surrounded by rock and gravel is provided to take care of underpiping, and a longitudinal drain 100 meters from the downstream toe collects the seepage.

Precast concrete sections and forms are manufactured in central casting plants. These are standardized into five or six sections. Irregular sections are used for forms and as a part of gravity sections. Thin reinforced concrete sections are used as forms for lock walls, piers, and powerhouse walls. These sections are cemented in place and remain a part of the structure. In powerhouse and other nongravity sections, concrete bases, walls, and floors are poured and the remainder of the section remains a void. The Soviet engineers estimate that this type of construction permits a saving of about 30 percent in the amount of concrete comprising a section, a saving of about 65 percent in the cost of concrete over that using wood or metal forms, and an overall saving in the cost of the entire project of about 40 percent.

There has been only one large dam constructed in the United States by the hydraulic-fill method. For many years levees along the Mississippi River at certain locations have been constructed by hydraulic fill, by the use of hired labor with Government-owned plant and by contract with private corporations. Revetment and bank protection measures have also been accomplished using precast reinforced concrete sections and asphalt mat, normally by hired labor with Govern-

ment-owned plant. This procedure has recently been accomplished under cost-plus contracts using Government-owned plant. The large investment required in the highly specialized equipment needed for casting and placing the precast sections, and the year-to-year schedules of work, militates against the investment by private enterprise in equipment necessary to perform this type of work.

The types of streams on which most multiple-purpose dams in the United States are located are not conducive to their construction by the hydraulic-fill method, as such procedure would necessitate construction of the required dredges on the site with resultant large mobilization and demobilization costs. The procedure of awarding contracts for large dams by competitive bidding also places a limitation on construction by hydraulic-fill method. Construction by hired labor or force account using Government-owned plant under present regulations requires a careful Government estimate or bid, competitive with the bids of private interests, including a certain cost differential between the two bids.

The construction schedule on projects in the United States is entirely dependent on annual appropriations. Even though continuing contracts are awarded for an entire large project, or for a large segment of such project, such continuing contract is still dependent upon annual appropriations, with very little leeway. This procedure is not always the most economical method. In the Soviet Union a project assignment is made, a schedule drawn, and funds for carrying it out provided. Every effort is made by the project personnel to complete the project on or ahead of schedule. The economic effects of the project on the overall economic condition of the entire country is considered, as the Soviet engineers estimate that each dollar spent on hydroelectric development will require the expenditure of about $10 additional for industrial and other development.

It is believed that the possibility of extensive use of precast forms and sections on resource development projects in the United States should be carefully considered. It is realized that the adaptation of this method of construction within the framework of the policies and procedures used by our agencies would not be easy. Due to the large investment in plant required for this work and the dependency on annual appropriations, it might prove more economical to perform this work by negotiated or cost-plus contracts using Government-owned plant. A proper long-range program for the development of the water resources of our Nation would permit moving Government-owned plant from a project being completed to another one being started as is presently done in the Soviet Union.

It does not appear that the design of projects in the Soviet Union provides a factor of safety as high as similar projects in the United States. In many of the construction projects in the U.S.S.R. it appears that considerable savings in cost have been effected by the elimination of spillways and overflow sections in the dams, and construction of controlled outlets and/or sluices through the powerhouse or nonoverflow sections, for the passage of flood flows through the dams. It is believed that in many of the projects in the United States where the spillways costs are very high, often exceeding the cost of the remaining portion of the dam, elimination or reduction in size of the spillways would result in a marked reduction in costs of the project.

IRRIGATION IN THE U.S.S.R.

(By Michael W. Straus)

In total irrigated acres the U.S.S.R. says it is surpassing the U.S.A. The U.S.S.R. is continuing its irrigation program under a firm policy of multiple-purpose river development of the full potential development. The United States has greatly retarded its program while debates over economy and agricultural surpluses continue.

All Soviet irrigation is governmental. A minority of U.S. irrigation is governmental. This lesser part will continue to shrink under a "do it yourself" proclaimed Federal policy to get private or public agencies, on lower level than the National Government, to assume a large proportion of the irrigation burden.

Senate observers saw irrigation works in the U.S.S.R. under development with far less intensity than power projects. At Stalingrad on the Volga, power facilities are being rushed at a furious pace with a barely observable start made on the 2.5 million acres scheduled for irrigation by gravity from Stalingrad reservoir. This mere token start was cited by officials as evidence all the irrigation facilities will proceed as planned "later." Other new extensive irrigation was seen in European Russia, in the Ukraine and the Rostov area from Tsimlyanskaya Sea, the reservoir behind the same-named dam which was completed in 1952 as an incident to the Volga-Don Canal endeavor.

U.S.S.R. officials cited statistics to illustrate their irrigation effort and pace over the past 30 years. In 1928, the total Soviet acreage under irrigation was listed as 10.6 million acres. In 1939, it was given as 14.8 million acres. For 1941, there were reported 15 million acres. By 1956, with obviously sharper statistics, and complete breakdowns, and finer scorekeeping, 27.1 million acres were reported watered.

As in the hydropower river development the irrigation endeavor is marked by the vast size of projects and a focus on Siberia—naturally on the dryer Central Asia areas with the longest frost-free growing areas. Described to the Senate observers, who did not eyewitness them, were the Kzyl-Orda area on the lower Syr-Dar'ya River where a thousand-mile canal is to water 4,942,000 acres of new land, the Turkestan area where another long canal brings water to 288,365 acres, Tashkent where works underway were scheduled to irrigate 735,000 acres next year from the Ili and Chu Rivers, the Samarkand and the Kara-Kum irrigation development.

The south-central Asian irrigation program embraces much cotton advanced to free the U.S.S.R. from dependence on imported fabrics and the fruits and early season crops not grown in northern areas. The works viewed showed few innovations in the 2,000-year-old art of irrigation but appeared sound and effective.

Relatively the Columbia Basin project in the State of Washington, largest single irrigation project in the United States with 1 million acres to be irrigated eventually, has been cut back and delayed with about a third of that area already watered and no date for completion firmly fixed.

In listing relative U.S.A.-U.S.S.R. figures one encounters an extreme variance in scorekeeping and categories called "irrigation."

The U.S. Bureau of Reclamation reported 7,827,000 irrigable acres in 1958. Of these, 6,756,000 acres actually received water that year. This contrasts directly with Soviet reports that its Government—2 years earlier in 1956—irrigated 27,100,000 acres.

For 1954—still 2 years earlier—there is another governmental figure covering bringing water to land for agricultural purposes by any method and by any agencies, public or private. This lists 29,552,000 acres as the total inventory of the last prior U.S. agricultural census.

RELATIONSHIP OF FISH MANAGEMENT TO HYDROELECTRIC DEVELOPMENT IN THE U.S.S.R.

(By Vic Reinemer)

Fish is a major food in the Soviet Union. Sturgeons produce the Russians' beloved caviar which, at a number of meals during our tour of the country, preceded fish soup, which preceded fried fish. Thus it is understandable that the Soviet Union endeavors to safeguard and enhance fish resources in connection with its hydroelectric development program. Engineers told me they were required to consider fish resources in planning hydroelectric development.

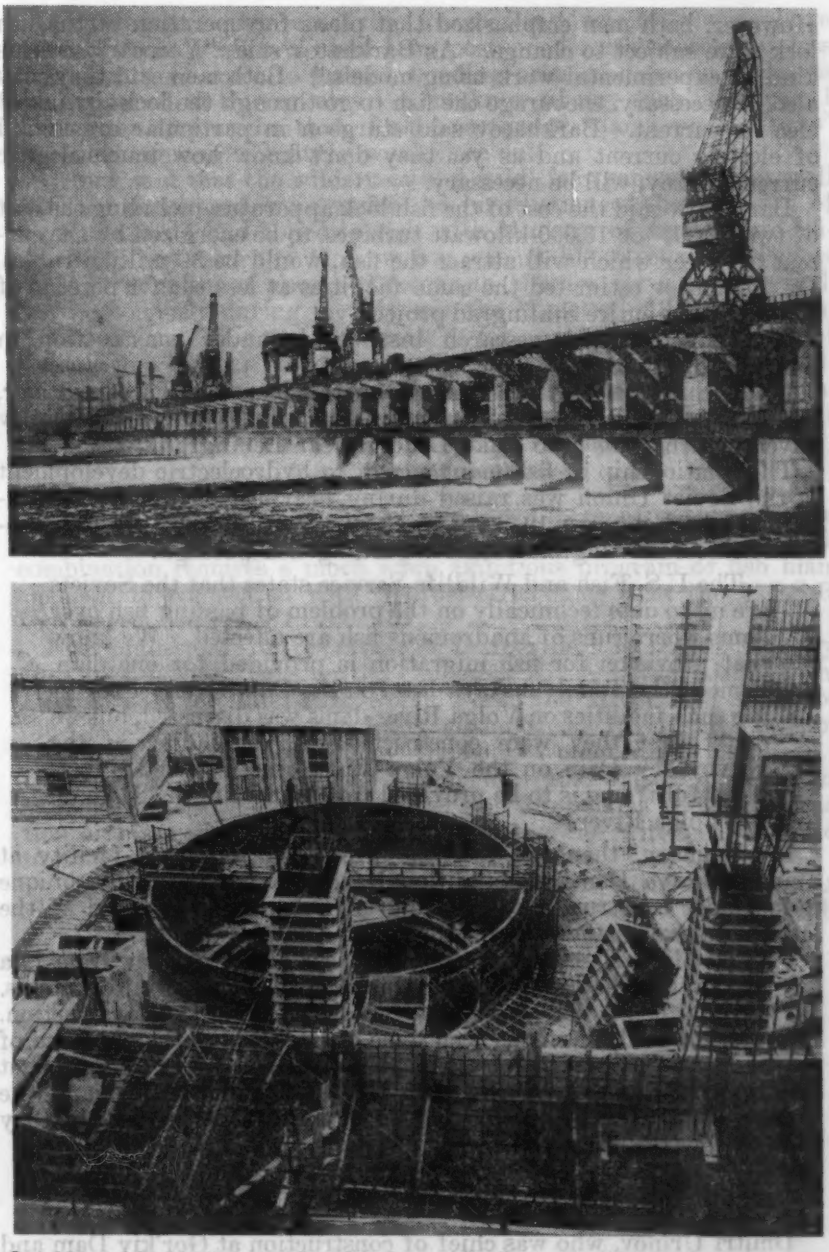
Furthermore, Soviet citizens highly regard species of fish which are shunned in this country. I asked one engineer what steps were taken to remove rough fish from reservoirs and supplant them with more desirable varieties. He replied that his countrymen take the view that most or all fish are desirable and that they do not take the pains we do to cultivate certain species.

We saw one fish elevator in operation, at Tsimlyanskaya Dam on the Don River. Its dimensions were 5 meters by 7 meters by 35 meters. One complete operation of the elevator requires approximately 45 minutes. During peak season (July and August) the lift completes a cycle every 1½ to 2 hours, carrying about 1 ton of fish each time. The fish are attracted to the elevator by a current of water, then moved by net to the tank which is lifted to the level of the reservoir above the dam where they swim free. Several varieties of fish are lifted, sturgeon being the one of most commercial significance. We were told that the success of the fish elevator at Tsimlyanskaya Dam had encouraged Soviet designers to include fish passageways in other projects as fish had multiplied and increased in size in the huge reservoir impounded by the dam.

FISH WILL RIDE WITH BOATS

At Stalingrad Dam on the Volga River we saw a fish elevator and unique fish locks under construction. The elevator will be approximately in the center of the main structure. The fish locks are actually the navigation locks. The chief design engineer of the Stalingrad project, Dr. Andrew Michailov, told me this is the first time they are trying to get the fish and boats into the same lock. He said they plan to attract the fish to the two parallel locks by a current of water, up to 100 cubic meters per second in volume, flowing at from six-tenths to 1 meter per second velocity, with provision made to increase velocity to 1.5 meters per second if necessary. Fish can be taken both upstream and downstream by this device.

The assistant director of construction of the Stalingrad project, Vladimir Adrianovich Barkhatov, said the volume of water used in the locks would be 250 cubic meters per second, at a velocity of four-tenths of a meter per second. His and Dr. Michailov's figures differ.



Outside and inside the next "world's largest." On top is Stalingrad Dam across the Volga River, already in operation but not yet completed. Below is a 115,000 kw. generator being installed to join similar machines already spinning. At bottom is an excellent example of Soviet use of precast concrete forms for pouring reinforced concrete (steel reinforcement already in place). Forms remain after pouring, as facing on completed monolithic structure, avoiding time and expense of form removal. When all generation is in place, Stalingrad will take the title of world's biggest kilowatt producer from its upstream teammate, Kuybyshev.

However, both men emphasized that plans for operation of the fish lock were subject to change. As Barkhatov said, "You can't do this kind of experimental work using models." Both men said they may also, if necessary, encourage the fish to go through the locks by use of electric current. Barkhatov said sturgeon in particular are afraid of electric current and as yet they don't know how much electric current, if any, will be necessary.

Barkhatov said the cost of the fish lock apparatus, including the cost of two 12,000- or 13,000-kilowatt turbines, to be energized by the current of water which will attract the fish, would be 30 million rubles. Dr. Michailov estimated the same facilities at less than 1 percent of the cost of the entire Stalingrad project.

A fishing industry research institute is under construction in Stalingrad.

I was told that fish ladders are operated on the Tuloma River, which flows into Barents Sea near Murmansk, and the Volkhov River, which flows into Lake Ladoga near Leningrad.

The relationship of fish management to hydroelectric development in the Soviet Union was raised during hearings on Senate Resolution 248 in February 1958. The Corps of Engineers' witness submitted the following statement regarding fish passage:

> The U.S. Fish and Wildlife Service states that the Soviets are up to date technically on the problem of passing fish over dams where runs of anadromous fish are affected. We know that provision for fish migration is provided for one dam, namely, the Tsimlyanskaya Dam on the Don River. Providing such facilities on Volga River dams was discussed, but we doubt that they were constructed. A fish ladder at the Kuybyshev Dam on the Volga River was canceled. It is doubtful if one is to be provided for the Stalingrad Dam on the Volga River.

In summary, then, we saw the previously reported facility at Tsimlyanskaya Dam, saw additional facilities including the unique locks under construction at Stalingrad Dam, and were told of the ladders on two northern rivers, the Tuloma and Volkhov.

I asked Michael Sarkisov, chief engineer at Kuybyshev Dam if a fish ladder there had been canceled, as reported in the United States. He said that fish ladders were not even discussed during construction. However, he said, there has been some criticism since then because of no provision for anadromous fish. He said they are thinking about doubling the capacity of this dam—presently the largest one in the world—and that if they decide to increase the capacity of the dam they will consider the fish problem.

POWER AND WILDLIFE INTERESTS CONFLICT

Dmitri Urinov, who was chief of construction at Gor'kiy Dam and who accompanied our delegation on part of the trip, gave me an interesting sidelight on the fish problem. He said there are several organizations in the Soviet Union devoted to preservation of wilderness and wildlife. He is a hydroelectric engineer, more interested in kilowatts than fish. His conversation indicated that fish and power interests conflict at times in the Soviet Union, even as they have been known to clash in the United States.

I asked several engineers if they knew of any instance where release of water from a reservoir had been postponed, with consequent loss of kilowatts, in order to prevent flooding nests of geese or ducks, as has happened in this country. None knew of any such instance. I gained the impression that if this particular "dams versus ducks" argument came up the ducks would lose out.

Urinov said that the wilderness and wildlife organizations, as well as fish management, were under the jurisdiction of the Ministry of Agriculture. I had hoped to visit with Ministry of Agriculture officials upon our return to Moscow, but was unable to set up any interviews in advance or upon our return to Moscow for a brief period. Our host agency during the trip was the Ministry of Power Station Construction. This was fortunate, as far as the primary purpose of our mission, but presented problems for those of us who sought collateral information from the Ministry of Agriculture. There undoubtedly is liaison between the two Ministries, but we saw little evidence of it.

U.S.-U.S.S.R. COMPARISON

The U.S. has in the Columbia River Basin its principal anadromous fish, the salmon, and also numerous multipurpose damsites. This combination requires a much more ambitious program of fish management in connection with hydroelectric dams than the U.S.S.R. has or needs to have.

Fish ladders are in operation at Bonneville, the Dalles, McNary, and Rock Island Dams on the Columbia River, Pelton Dam on the Deschutes River, Cazadero, North Fork, and River Mill Dams on the Clackamas River, Swan Falls on the Snake River and Lewiston Dam on the Clearwater River. These and other dams also have a variety of other fish devices—skimmers, traps, bypasses, collections systems, locks, passageways, hatcheries. Most dams under construction or planned in the Columbia Basin likewise will have facilities to safeguard and enhance fish values.

Minor fish management gear, such as screens, attractors and barriers, is found at dams in the Missouri, Colorado, Rio Grande, Gulf, Arkansas-White-Red Basins and California's Central Valley.

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RECREATIONAL USE OF RESERVOIRS IN THE U.S.S.R.

(By Vic Reinemer)

We saw a number of rest homes and sanitariums on the banks of reservoirs. Some of these were located on recently filled reservoirs, such as Tsimlyanskaya Sea, indicating recent construction. The director of the Leningrad Hydroelectric Design Institute, Peter Yanofsky, said consideration of recreational values in dam design is obligatory.

We were told that beaches and sport facilities are planned for Krasnoyarsk Dam, which is just going into construction. At Stalingrad Dam, Director of Construction Aleksandrov said they plan to develop parks, as well as orchards and vineyards, in the 2.5 million acres to be irrigated from the reservoir. At just-completed Irkutsk Dam on the Angara River, Chief Engineer Sergi Moiseyev told me they are planning and building boat houses, fishing camps, and rest homes.

I visited with a number of Soviet vacationers. Some were camping, some were touring by bus, others were in hotels at Sochi, a Black Sea resort. The campers told me they paid 200 rubles ($20 at the U.S. tourist rate of exchange, $50 at the official rate) for a 20-day stay at the campground. This payment covered use of the tent and fixed menu meals. Their union, in effect the Soviet Government, paid the other two-thirds of the 600-ruble charge.

This system whereby the worker pays one-third the cost of the vacation and the union the other two-thirds appeared to be widely used. In the Ukraine en route from Kharkov to Kremenchug Dam by car I saw what appeared from the road to be a pleasant campground with some cabins and a big sign overhead, in English, "CAMPING".

From what we saw and heard it seemed apparent that Soviet use of reservoirs for recreational purposes does not begin to approach the level enjoyed in this country where in 1958, 19.5 million visitor days were spent sightseeing, catching 10 million fish, shooting 180,000 ducks and geese plus other game, boating, water skiing, picnicking, swimming, and camping at 163 Bureau of Reclamation reservoir areas, with additional numbers in like pursuits at Corps of Engineer reservoir areas.

Unfortunately a tight schedule and inclement weather precluded any firsthand participation in outdoor recreation in the Soviet Union, except for a brief boat ride on Lake Baikal in Siberia. We saw quite a few fishermen, particularly on Lake Baikal. We were told that there is no creel limit in this area but that fishing is permitted only on Saturday (until 3 p.m.) and Sunday (all day).

RELOCATIONS OF POPULATION AND INDUSTRY

(By Theo W. Sneed)

The construction of large multiple-purpose projects on the many rivers of the Soviet Union has created a vast problem of relocation of population and industry. Although the primary purpose of development has been for the production of hydroelectric power, effects on other segments of the economy have been significant. New economic provinces, including new industrial and agricultural complexes, have been established based on the development of the streams, and for dispersing industry and population throughout the Nation. Power development is not considered entirely on the basis of its need in the area, they relocate or develop industry in the particular area to use the power, or transmit the power over long distances to points needed.

The large reservoirs associated with the projects, many of which cover thousands of square miles of area, have created the problem of relocating the towns, villages, and improvements within such area. The question of acquisition of land in the reservoir area is of no particular import, since ownership is vested in the Government which has absolute control over the disposition of the land. Villages and towns in the area to be inundated are usually moved to higher land around the reservoir area in the same district or abolished. Construction of the Kuybyshev Dam on the Volga necessitated the relocation of an estimated 150,000 people. Ports and other dock and navigation facilities are usually rebuilt. Levees and dikes are frequently constructed to protect villages or industries from flooding when such procedure is deemed economical. Construction of the Gor'kiy Dam on the Volga River necessitated the construction of 84 miles of dikes.

Along with construction of these projects, new modern cities are built, primarily for housing the employees working on such project. These cities are complete with gas, water, electricity, theaters, parks, stadiums, and wide streets. Some of the people relocated from the reservoir areas are moved to these cities, and they are also used by employees of industries associated with the project or moved to the area. The new cities at Stalingrad and Kremenchug projects now under construction have a present population of approximately 45,000 people each, and in the Kuybyshev Reservoir the entire city of Stavropol', with a population of 25,000, was moved to a new site. These new cities are also used for the permanent employees needed for the operation of the power and navigation facilities of the projects.

Prior to evacuation of a reservoir area, a commission is established to set a price on the buildings and other property in the reservoir area. Collective farms and others who have built their own homes in the area are paid at the prices established by the commission. At the Bratsk project it was estimated that 14,000 houses were removed

from the reservoir area, and the timber cleared from such area was used in construction of new housing for the families relocated. Since the state subsidizes all functions of water resource development, they paid for the new housing and cleared the land for farming in the new location, new boat harbors and fish hatcheries were constructed to replace those destroyed. On the project $42 million was paid to the Ministry of Transportation for the railroads relocated.

At the Kremenchug project on the Dnieper River, approximately 100,000 people required relocation from the reservoir area. A construction city of about 45,000 population was built. It is named Khrushchev. Many of the workers came from other sections of the country, but many of the relocated families were moved to the new city and new villages constructed for others. A portion of the construction city has been charged to relocations and a portion to industry. In all cases an effort has been made to raise the standards of living of those people relocated. The Kremenchug Reservoir cannot be filled until the cemeteries have been removed from the reservoir area and certain other sanitary measures carried out.

CONTRASTS BETWEEN U.S.S.R. AND U.S.A.

(By Michael W. Straus)

The Senate observers saw nothing in the Soviet program in the nature of a scientific, engineering, or technological breakthrough assisting the Communists to push their power program ahead of the United States.

Their practices are bold while all procedures, technique, and know-how appeared to be, and to have long been, familiar to American engineers engaged in similar endeavor.

All installations viewed were devoid of advances into new, and heretofore unexplored, ground in the nature of the U.S. breakthrough in the fields of fusion or fission or the Russian rocket performance. This applies to the important use of prefabricated concrete and the employment of mercury arc rectifiers in excitation of large generators, noted elsewhere in this report. While the Russians do employ widely such devices and prize them, both have been applied previously in America, understood, and sometimes discarded because of preferences, environment, and different economic and working climates.

Evidence accumulated before the observers that the U.S.S.R. totalitarian and monolithic system of government fosters pushing their power program faster than one under the democratic American Government. This evidence is factual and cited without connotation as to broader political philosophy or preference.

LEGISLATIVE SIMPLICITY

In essence, in the U.S.S.R., where the state is supreme over the individual, power projects are authorized and embarked upon by a process of relatively extreme simplicity having the effect of foreclosing delays resulting from political debate.

In effect, the executive agency of government (indistinguishable from and never in conflict with the Communist Party) decides to go ahead with some project. This decision is preceded by whatever study the executive deems wise or necessary. This study is frequently of an expert and high-caliber nature, and can be exhaustive, but in all cases the party decision is final. The project is then defined, formally published, and presented by the chairman of the party to the Council of Ministers (composed of party leaders) who unanimously approved it. Likewise, it goes to the Chamber of Deputies, which, as a legislative body, has but few of the democratic prerogatives of the U.S. Congress, and is not on record, or likely to be, as ever rejecting a party proposal. By the Council of Ministers' directive (sometimes called decree) it then is embraced as one item in the 5-year or currently the 7-year plan.

Omitted from this procedure, and in striking contrast to the U.S.A. form of government, is the entire, established setup of budget review or reversal, committee consideration and floor debate in two Houses of Congress, followed by conference reconsideration, passage, enactment or veto, and overriding or upholding the veto. All this precedes mere authorization, and not building or completion of a project. Most of these requirements are incorporated in the Constitution, laws or rules, for the express purpose of protecting the individual, or property, from the state. They therefore inherently insure that American democratic action contrasts with Communist totalitarian action. They likewise result, by the record, in delaying many projects through many Congresses before only authorization is attained.

APPROPRIATIONS

In the U.S.S.R. system, once a power project is authorized and embraced in a 7-year plan, it is implemented by authority, materials, manpower, and money stretching over a 7-year plan. Completion of a project on schedule—or earlier—is required. The responsibility is fixed. Explanations of failure or delay are out of order. Recently there has been turnover among state ministers of power. One Senate observer last summer knew Aleksey S. Pavlenko as Minister of Power Station Construction in the U.S.S.R. This summer I. T. Novikov was Minister of Power Station Construction. No explanation was forthcoming as to the shift. Pavlenko was nowhere in evidence around the ministry nor were any officials able to recall where he went.

In the U.S. democratic system after authorization a project comes right back to go through the whole congressional route a second time before actual construction. This time it proceeds via the appropriation machinery with the appropriation an absolute control on any construction as well as the schedule of construction. Sometimes it gets no appropriation and does not even start. At other times, it is modified almost beyond recognition by appropriation law stipulation. At best a multiple-year construction project can only get annual appropriation without future financing assurance. Therefore there can be no assured schedules, although Congress is frequently generous and provides money that in the end permits schedule construction. There is not, and there cannot be, short of an upheaval, any 7-year-plan financing assurance in the U.S.A. At the Soviet rate of construction, 7 years cover all projects from start to finish—usually on or before schedule.

RELOCATION

Only one more specific example of how the Communist system of government forwards the U.S.S.R. power program is offered. It is selected because most officials are familiar with the terrific and time-consuming debates on all levels apparently inherent in the essential clearance of people and things from a reservoir behind a dam before it can go into operation. These involve items of high emotion ranging from the ruination by submerging of grandfather's homestead, through Indian treaty rights to violation of the dead in a graveyard on up to high finance and debate over how fancy a new section of railroad the Government must build a corporation in lieu of the stretch

relocated from the reservoir area. Such difficult problems in the U.S.A. frequently and properly get to court—and stay there for years.

In the U.S.S.R. Stalingrad Dam today is backing up a reservoir over a considerable section of the fertile Volga Valley. The reservoir was growing as the Senate observers watched—and inquired as to relocation difficulties and delays. "There were none," Chief Construction Engineer Alexander Alexandrov assured the observers.

There were two railroads and a highway that had to be relocated out of the reservoir area and run over the dam, but that was no problem. The railroads were Government owned, and the dam was Government built, so the Government had no difficulty reaching an agreement with itself and a resultant settlement.

There really was no more difficulty relocating the 100,000 persons who had to be moved from homes in the reservoir area, Chief Engineer Alexandrov explained to the observers. The fascinated Americans who had bled through relocation battles at home never dreamed it was politically possible to relocate 100,000 citizens. This has never even been attempted in the democracy—and is not likely to be by anyone familiar with the inevitable turmoil that would result.

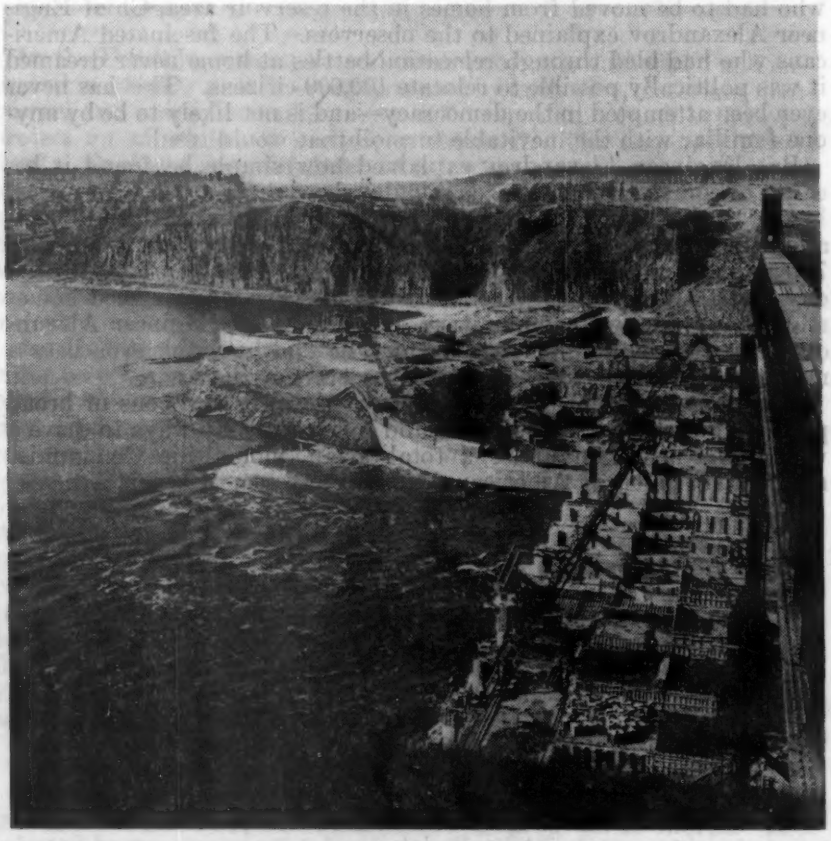
But Engineer Alexandrov explained how simple he found it because, of course, the homesteads inundated were all on U.S.S.R.-owned land. So he built the evacuees new, and he believed better, communities outside the reservoir area, also on Government land with 7-year-plan funds provided for that purpose. On the predetermined day the 100,000 citizens were invited to quit their established homes and occupy the new communities. They moved. Engineer Alexandrov experienced no difficulty—in fact, he said he didn't even hear a murmur of protest. Neither did the observers on the scene.

It appeared evident that regardless of the pros and cons of broad political philosophy, it is simpler and faster in many ways to drive a vast power program under a totalitarian, monolithic Communist regime than under an American democratic system of government.

LARGEST U.S. AND U.S.S.R. DAMS (BY INSTALLED CAPACITY)

Name	River	Nation	Capacity (kw)	Status
1. Krasnoyarsk	Yenisey	U.S.S.R.	5,000,000	In construction.
2. Bratsk	Angara	U.S.S.R.	4,500,000	Advanced construction.
3. Stalingrad	Volga	U.S.S.R.	2,530,000	In operation.
4. Kuybyshev	do	U.S.S.R.	2,300,000	Completed (1957).
5. Grand Coulee	Columbia	U.S.A.	1,974,000	Completed (1950).
6. St. Lawrence	St. Lawrence	International (U.S. and Canada).	[1] 1,800,000	Completed (1958).
7. Hoover	Colorado	U.S.A.	1,249,800	Completed (1953).
8. Votkinsk	Volga	U.S.S.R.	1,000,000	In construction.
9. Saratov	do	U.S.S.R.	1,000,000	Advanced construction.

[1] 900,000 kw U.S. share.



Bratsk Dam, under construction, with the Angara River already closed off when the Senate observers viewed it October 10. This Siberian giant, with more than double the capacity of Grand Coulee, is scheduled for 1963 completion. Twenty units of 225,000 kw. each, whirling under a 102-meter head, will win it the "world's largest" title.

APPENDIX

(Directly pertinent to the subject matter this subcommittee studied in the U.S.S.R. is a new official Russian announcement of a 15–20 year Soviet power program, announcing a target of 2.3 trillion kilowatt-hours of power by 1980, as compared with the current 7-year goal of 500 billion kilowatt-hours by 1965. This announcement, in the form of a speech by Premier Khrushchev, was disclosed to all Russians over the all-Soviet "home service" radio network shortly after the Senate committee left the Soviet Union. Because of its import the full text of the speech is included as an appendix to this report.)

TEXT OF SPEECH DELIVERED BY NIKITA KHRUSHCHEV ON NOVEMBER 28, 1959, TO THE ALL-UNION CONFERENCE OF POWER INDUSTRY CONSTRUCTION, ENTITLED "THE IMPLEMENTATION OF LENIN'S IDEAS ON ELECTRIFICATION IS A SURE ROAD TO THE VICTORY OF COMMUNISM"

Dear comrades, allow me to greet you and to congratulate you, on behalf of the CPSU Central Committee and the U.S.S.R. Council of Ministers, on the great successes you have achieved, are achieving, and, we feel sure, will achieve in the construction of power stations, both thermal and hydroelectric.

REFERENCE TO SENATE DELEGATION

It is with pride that the Soviet people look upon your activity. The builders of hydroelectric power stations and the builders of thermal power stations carry high the banner of labor; with their creative achievements they have raised high the prestige of builders, the prestige of the great U.S.S.R. in the international arena. Americans who recently visited our country—who were not merely tourists but Senators and major experts who are well versed in questions connected with the construction of power stations—have a high opinion of our successes in the country's electrification.

This year the U.S.S.R. was visited by a delegation of U.S. Senators. They acquainted themselves with the construction of power stations. They had a look at the construction of 10 hydroelectric power stations on 7 rivers from the Ukraine through the area of Lake Baikal in Siberia. When these Senators returned to the United States, the U.S. press carried a report which stated: "Americans have become painfully aware of the Russian superiority in the study of space. A delegation representing two committees of the U.S. Senate recently returned from a month-long trip to the U.S.S.R. and has convincing proof that the U.S.S.R. has overtaken the United States in the field of construction of hydroelectric stations as well. We cannot afford to adopt a careless attitude toward the Russian program for the production of hydropower and toward this program's possible influence on international affairs. Underestimation of its scale and significance could prove as dangerous as a careless attitude toward the Russian progress in the field of the creation of guided missiles and rockets.

"Indeed, the power program—though it is less striking—might in the end be of even greater significance than the rockets or space research programs, because electric power is at the root of the industrial might of a modern state."

The American Senators admitted that the Russians now occupy the leading place in the world from the point of view of generation of hydroelectric power. You know that there was a time when we were learning from American specialists. We thanked them and even awarded decorations to some of them, such as Colonel Copper, who was consultant for the building of the Dnieper power station. Now they are not ashamed of their pupils—we must give them their due there. They have taken their hats off to the worthy pupils of good teachers.

We can say proudly and without conceit that we find the opinion of the American Senators and specialists agreeable. For the Americans are the strongest builders of hydroelectric stations and in the field of industrial construction as a whole. The American engineers and workers whose experience we utilized, as well as statesmen and public men, now admit openly in their press statements that they have something to learn from the hydropower station builders of the Soviet Union.

SOVIET PROGRESS IN ELECTRIFICATION

A long-term electrification plan is an integral part of the program of building communism. Our hydropower station builders have amassed a vast amount of experience. Together with the whole country they have traveled the path leading from the Volkhovstroy to Bratsk. For years I have had the opportunity of visiting the building sites of many hydroelectric power stations in our country. When I was still a workers faculty student, I came to Leningrad for the first time. At that time Volkhovstroy was part of everybody's life, and I very much wanted to visit the station. Former workers faculty students are no doubt present at this conference. They certainly remember very well that at that time we students did not have too much money.

I remember that students were issued railway passes. In order to see more than usual in one trip, I asked for a pass to Leningrad so that I might visit Moscow on the way home to the Donbas. One had to do all this in a short period of time because the ticket was valid for some 7 or 8 days. When I got to Leningrad I traveled to the Volkhovstroy. I shall frankly state that the Volkhovstroy did not produce a strong impression on me. Even at that time I had a different conception of the building industry. Later, in 1928, during a trip to the south, I called at the Dneprostroy and had a look at what was going on.

NEW CONSTRUCTION TECHNIQUES

The building of the Dnieper GES produced a might impression on me. First of all, its scale was considerably larger than that of the Volkhovstroy. Secondly, the technical equipment was different. Cranes powerful for that time were utilized at the Dneprostroy. Nowadays, of course, they would no longer be regarded as powerful. You

know that at that time almost all the work at building sites was done manually. A quantity of bricks was loaded in a barrow or a small truck which were then the main means of hoisting, and men pulled the load along.

Of course, in comparison with these means of lifting, even small cranes must seem very powerful. It must be said that at the Dnieper building site advanced techniques and manual labor went side by side. The building site was literally like an anthill, but without doubt it was different and higher level of construction than on the Vokhov building site.

In recent years, I have had occasion to visit the building sites of several power stations in Siberia. In particular, when we were returning from China in 1954, I visited the building site of the Irkutsk GES on the Angara. This year, I visited the Irkutsk station again. Its construction has now been completed. At one time we also acquainted ourselves with the building site of the power station on the river Ob, at Novosibirsk. At this site, hydro-mechanization was employed. There were no grabs. Powerful walking excavators were at work there. True, in this case they did not move. There was no room to do so. They did not move, but stood on one spot and operated that way.

Although it is a little late, the builders should still be criticized for an incorrect use of their machinery. I have already told the head of the Novosibirsk GES on the Ob that their machinery was not always being used correctly. It turned out that an excavator was needed on the site, but there were none at the works; there were only walking ones. "Let's have the walking one," they demanded on the site. But the fact that it would not move, and working it would be more expensive, were things the head of the site did not consider. If he had known that he would have to bear some material responsibility for the incorrect use of machinery, he would not have taken the walking excavator. That is what greed and extravagance sometimes lead to. Successes should be praised, and shortcomings criticized.

A VISIT TO BRATSK

Just recently, returning from China and the Far East, I visited the site of the Bratsk GES. Of course, the work here is going on at a higher technical level. I must admit that when I looked at the building works, I was simply struck by their skill, their agility, and the boldness of their work.

I like folk art. Sometimes I pay tribute to the remarkably agile and cheerful people who work in the circus. Can one compare even the most highly trained circus artist with those who work as spidermen and assembly workers, when these workers walk along girders over a hell of a drop?

During the visit explanations were given by the head of the building site, Comrade Naimuskin. He is here in the presidium. As to Chief Engineer Comrade Gindin, I do not see him. He apparently is staying at the building site. (Voice from the presidium: "No, he is here.")

I liked their explanations, but I was impressed most of all by the scope of construction and the organization of work at the building

site. We watched how the workers assembled one of the spans at a great height. I just looked up and said: "Let us go away. It can happen that some worker will fall down, and then people will say that he could have worked more carefully but during the visit decided to show his skill and daring and miscalculated."

Yes, these are remarkable people. They work selflessly under the severe conditions of the Siberian taiga. Now, it is true, the conditions there are substantially better than at the beginning of construction. There is a large town and production and living conditions are being solved.

The builders as a whole and the builders of hydropower stations in particular are people who pave the way toward what is new in life. Therefore they are called builders. But the ones who build hydropower stations are the first among those leading builders.

What is created by the builders of hydropower stations is, figuratively speaking, like the breath of the newborn child. The newborn child has emerged in the world; he lives, breathes, and gains in strength. The same happens with the builders of power stations; they seem to put a soul into their creation; it begins to breathe, power and light appear, motors and machines are humming, and tireless life starts even in those places where it has never been and where man had not set foot before.

Such a region is the area of the Bratsk GES and of the future Ust-Ilim GES building sites. The latter will be situated 250 to 270 kilometers north of Bratsk. The Bratsk GES builders are performing a heroic deed. You listened to a speech by Komsomol member, concrete worker Valentina Zharkaya. When you look at her, she seems to be a frail girl; it seems that strong and thickset people are required to mix concrete. However, machines and the automation of production have made it possible to count not on the muscles but on the brains, which do not depend, of course, on the physical strength of a worker.

It is pleasant and joyous to watch such workers and to listen to their wise speeches. Our youth and the Komsomol are pioneers at many building sites. Responding to the call of the party, they go with Komsomol travel vouchers to those parts of the country where new industrial centers are being built. They toil heroically under difficult conditions. Honor and glory to our youth, which boldly goes to unpopulated parts of the country and creates life there, creates the future, builds communism.

I attended the commissioning of the Lenin Volga hydroelectric station—the world's largest hydropower station. Last year we saw the construction of the Stalingrad hydropower station. I can see Comrade Aleksandrov, the head of that station's building site. He grumbled a lot at my speech to the effect that priority ought to be given to thermal stations. But I know that here he is not the only such grumbler. We have a lot of them.

I also went to the Kremenchug station. At the time Comrade Novikov headed the building site. I have also had occasion to visit other power stations. It was always with great satisfaction that I saw how quickly our technology (tekhnika) is growing, what remarkable people are developing, how everything quickly changes, and how Ilyich's behests about the country's electrification are being implemented.

LENIN'S DREAM BEING REALIZED

If Vladimir Ilyich Lenin could have a look at what the people have done, what miracles they work in transforming their free country, he would take off his cap and make a deep bow. The things Lenin lived for, the things he planned and dreamed of, are now being successfully implemented by our people and the party. In working out the Go-El-Ro [state electrification of Russia.—Ed.] plan, Vladimir Ilyich dreamed about our homeland's future, about communism. He looked a long way ahead. Even in conditions of destruction and starvation he kept on putting forward this very bold and majestic plan. At the time it was fantastic, inconceivable. An author of fantasies like H. G. Wells called Lenin a dreamer, a person who does not think realistically. What would Wells say now? Yes, our own Ilyich was a dreamer. He went on dreaming in harsh conditions, when the country was experiencing difficult days, beating off the domestic and foreign enemies of the revolution. He firmly believed in the strength of the people.

Lenin believed that electricity would be switched on where there had been wildness and barbarism, and would bring joy and happiness to the people. Lenin's great ideas, his brilliant plan for the country's electrification, the plan for the construction of communism, live and will live, inspiring our party and our people to new heroic feats in the name of the achievement of our ultimate aim.

Comrades, Vladimir Ilyich Lenin said: "Communism is the Soviet regime plus the electrification of the whole country." That was said with wisdom and perspicacity. What is the remarkable thing about this formula of Lenin's? First of all, that it gives a concrete and live idea about the tasks of the construction of communism. It leads the understanding of communism from the field of study-room concepts and places it on a real basis. It translates a general theoretical proposition into the language of the practical actions of millions of people who are building a new life. It happens that theoreticians can give general formulas, but they often do not know how to implement them and see to it that these formulas become full of life content and a guide for action.

Lenin's greatness lies in the very fact that he brilliantly combines theory by generalizing new phenomena of life, could notice the main trends in the development of society, and armed the party and the working class with a clear program of the construction of Communist society. The brilliance of Lenin's formula lies in the fact that it presents in unbreakable unity the political—"the Soviet regime"—and the economic—"the electrification of the whole country"—aspects of the construction of communism. How Leninistically simple and clear: the Soviet regime plus electrification.

The political aspect is a question which has already been solved. The Soviet regime is truly popular, the most durable regime. The whole Soviet people has convinced itself through experience that the Soviet regime is the best form of political organization of society, a form which gives the greatest possible scope to the development of the creative forces of working people, their active participation in the construction of a new life, in the running of society. All this has entered into the consciousness and daily life of Soviet people. This is nurtured by the whole structure of life. It enters people's minds at

school, pioneer, Komsomol, trade union, soviet, party, and all public organizations. Society develops, and the consciousness of all its citizens also grows.

THE IMPORTANCE OF ELECTRIFICATION

The economic aspect of the construction of communism—what Lenin expressed with the words "plus the electrification of the whole country"—is acquiring increasing importance, I would say decisive importance, at the present stage. What is the electrification of the whole country? It is the supporting structure for the bases of development of the national economy. Without the implementation of electrification one cannot, at the present stage, move forward successfully and quickly in either heavy industry or construction, transport or agriculture, or the production of consumer goods; one cannot raise the standards in production and everyday life. To electrify the whole country is to give mighty energy to the new society, to speed up the development of our productive forces. A society in which power belongs to the working class, to the toiling people, gets its first opportunity of developing its economy according to a single plan, according to the interests of the people. The working class needs political power not for its own sake but to insure an abundance of material and spiritual goods for all members of society. And this cannot be achieved without a mighty upsurge in all branches of the national economy, without an incessant increase in the productivity of public labor.

In the creation of a Socialist economy and the construction of communism an important part is played by the state. But we are marching along the road of a gradual dying off of the state, which will become extinct with the complete victory of communism. The working class thus uses political power to develop society's productive forces more quickly, to create an abundance of all that man needs to completely satisfy his growing material and spiritual requirements.

After gaining power, the working people are interested in the creation of a mighty and quickly developing economy. This can be achieved only on the basis of the country's industrialization and the electrification of the national economy, which enables us to produce the necessary output now with machinery rather than muscular force. Electrification insures the large-scale utilization of machinery and technical progress, the toilers produce more goods for the benefit of society by controlling machines, and with the minimum expenditure of energy and means.

Our country has entered into the period of large-scale construction of the Communist society. Both theoretical and practical questions of Communist construction become highly important under present conditions. We are faced with the task of drawing up the party's program which will be considered at the next, the 22d Congress of the CPSU, which, as is known, must be held in 1961.

The decision to draw up the new party program was taken as far back as the 18th congress. But things dragged on, and that may perhaps be for the better. Now we have possibilities for looking wider and farther afield. The party has amassed rich experience, and on the basis of its generalizations, on the basis of the successes in the

country's development, it is now possible to work out the program more profoundly, and to determine the main tasks and paths of construction of a Communist society.

Comrades, the problem of electrification, the building of mighty power systems, the problem of the creation of communism's material and technical bases, must be main items in our party program. Lenin taught that it is necessary to insure the highest productivity of labor for communism's victory. Without this productivity a successful advance toward communism cannot take place. High labor productivity in a Socialist society is achieved by a fuller and wiser utilization of the accomplishments of modern science and technology. The application of the power yielded by mighty electric stations sets in motion modern machines, lathes, and automatic tools. Electrification insures the large-scale mechanization and automation of production. Conditions are thus created for the transition to Communist labor, to a Communist society.

For this reason the long-term 15- or 20-year plan for the country's electrification the long-term plan for the development of the national economy over the same period of time, must become the main pivot of our communist construction program. The long-term plan for the country's electrification is not a fantasy but a reality, having practical foundations in the form of a mighty Socialist economy. Now even the enemies of socialism can no longer deny this fact. Our successes in the development of the economy evoke their anxiety. They are afraid of our successes, which vividly demonstrate the superiority of the Socialist system over the capitalist one. Competition is developing between these two systems. We are for peaceful coexistence of states with different social systems, for their competition in the economic field.

As far as relations between Socialist and bourgeois ideologies are concerned, there can be no coexistence and we do not conceal this. The progressive has been and will always be victorious over the moribund and the dying. It is true that moribund parts of an organism, before they are removed, sometimes cause diseases, create much unpleasantness, as, let us say, in appendicitis. But a healthy organism is always victorious at the end. In social development the juster Socialist system is achieving and will achieve victory; the advanced Communist ideology will be victorious.

PRESSING PROBLEMS OF ELECTRIC POWER CONSTRUCTION

Comrades, I would like now to dwell upon some concrete problems concerning the further development of power engineering. A fortnight ago, I received the Minister of the Construction of Power Stations, Comrade Novikov, and his deputy, Comrade Neporozhnyy. We agreed that the Minister and a group of experts would come to the south where I was going and, on the shores of the Black Sea, we would thoroughly discuss all problems concerning the further development of electrification, where nobody would interrupt us, where there would be no telephone calls and other interference. We did it. I must say that I listened with great satisfaction to Comrades Novikov and Neporozhnyy, to designers of turbine works Comrades Shubin-Shubenko and Shcheglev, the head and chief engineer of the Gidro-

Proyekt, Comrade Russo the chief engineer of the Glav-Energo-Proyeko, Comrade Chyuprakov, the chief engineer of the Gidro-Energo-Proyeko, Comrade Borovoi, and the deputy chief engineer of the Teplo-Elektro-Proyekt, Comrade Zhilin. We sat for 8 hours, conscientiously worked the whole day, and were well satisfied with our discussions.

The comrades reported on the possibility of carrying out the complete electrification of the country within the next 15 to 20 years, taking into consideration the satisfying of electric power needs in all branches of the economy, including all the requirements of industrial and collective farm production, and also a rapid increase in the consumption of power for satisfying communal and everyday needs of the population: lighting, electric household appliances, radio sets, television sets, preparing food, heating water, etc.

It is also planned to have a wide-scale development of current-consuming branches of production on the basis of cheap power supplied both by powerful thermal power stations burning coal mined in open-cast mines and by large hydropower stations being built on the central Siberian rivers.

FUTURE ELECTRIC POWER PRODUCTION

The Ministry's preliminary calculations show that to meet these demands and to insure a still faster rate of development of power engineering it is essential to produce 900 billion kilowatt-hours of electric power in 1970 about 1.5 trillion kilowatt-hours in 1975, and about 2.3 trillion kilowatt-hours in 1980. This means that in 15 to 20 years the capacity of power stations will have to be increased by seven or eight times. How can the rapid growth of our power system be implemented? Through the building of large thermal power stations, with capacities of 2.4 million kilowatts and over, working off cheap coal, oil, and gas, with turbogenerators of 300,000 kilowatts and over, and also by highly economical hydroelectric power stations with capacities of up to 5 or 6 million kilowatts and aggregates of up to 500,000 kilowatts.

Apart from the building of power stations, hundreds of thousands of kilometers of high-voltage main and secondary networks have to be built in all the Republics of the Soviet Union. The extensive program of power station construction sets a great task for the power machinery building works. They must create in a short time new forms of powerful and economical equipment for power stations and networks. Industrial methods of erecting buildings; and construction with preassembled ferroconcrete components, blocks and factory-prepared parts, must be extensively introduced.

It is desirable that thermal power stations should be constructed up to 90 or 95 percent from preassembled parts, and hydroelectric power stations should be so constructed up to 70 to 80 percent; that construction sites must be turned into assembly sites, that parts for the buildings must be prepared at centralized regional bases of the building industry and at specialized enterprises. The fulfillment of these conditions will make it possible to considerably lower costs and curtail the construction period, both of thermal and hydroelectric power stations. This will gain much time for us in the peaceful

economic competition with capitalism and insure that the country has cheap electric power.

TOTAL ELECTRIFICATION THE GOAL

Our country has achieved such a high level in the development of our economy, science, and technology that we can embark on and implement in the next 15 to 20 years the task set by the great Lenin: total electrification. This is a great and noble task. It is understandable that all the questions regarding the solution of this task must be well thought out from every angle. To do this, a commission must be set up in which experienced specialists must take part. It is essential to integrate the development of power engineering with the long-term plan for the 15-year development of the national economy which is being worked out by the Gosplan. This plan will really be a program for the building of communism.

Now I would like to make a few observations on this question: Which is the more expedient, to build hydroelectric power stations or thermal power stations? To put the question of which is better, comrades, is the same as arguing which is the best way to eat bread: with or without butter. In my opinion, it would be silly to argue. If there is no butter and little bread, then it is good without butter, but if there are stacks of bread and butter, then it is good with butter. Or let us take another comparison. Let us say that you wrapped up a hydroelectric power station in one bag and a thermal power station in another one for me, the chairman of the Council of Ministers, and said: "There you are, Comrade Khruchshev, take your pick, the hydroelectric or the thermal power station." The cost per kilowatt-hour from the hydroelectric power station is, let us say, half a kopek or a kopek, and from the thermal power station, let us say, five kopeks. I think, comrades, with such a proposal, each of us would give preference to the hydroelectric power station.

I would say: "I choose the station which produces a kilowatt-hour for half a kopek, and shelve the thermal station." But that is true when I can choose the one or the other. Yet when you say: "We will give you a cheap hydropower station, Comrade Khrushchev. It will produce a kilowatt-hour of power 6 or 10 times more cheaply. But you will get it 5 years later than its thermal counterpart." Then I must do something.

Even a fool can understand that the power produced by a hydroelectric station is cheaper. But the question is what is more advantageous, if one takes account of the time it will take to get the power. Will it be advantageous to build the station which will yield power 5 years later? That is worth thinking about, because we can lose 5 years in our competition with capitalist countries.

THE NEED FOR SPEED IN CONSTRUCTION

Let us look at the recent past of our homeland. In 1941 Hitler started a war against the U.S.S.R. which lasted almost 4 years. These years could have been fatal if our country had not managed to create in a short period a mighty industry and a highly developed agriculture. So by running after cheapness and ignoring construction time

one might not only fail to consolidate gains, but also lose and waste what one has achieved. That is what it is all about.

In the economic competition with capitalism, the question of gaining time, the question of the time it takes to solve economic tasks is of exceptional and vital importance. The U.S.S.R. and all countries of the Socialist camp constitute the new world. Over a billion people are marching under the banner of Marxism-Leninism. Socialist countries are successful in their development. Now our forces are mightier than the forces of imperialism. But capitalism is still strong. And we may not ignore its strength. Many capitalists now shake our hands, although some of them still greet us without any special desire but under the force of circumstances. They are forced to do this. You have seen the well-known painting by the artist Pukirev called "The Unequal Marriage." The painting depicts the most solemn moment in man's life—a wedding. Under the crown there is a rich old man and a poor young beauty. It is as though she had gotten into the cage of a wild beast. They forced her to go to the altar. She cannot escape her lot. She has nowhere to go. Some rich gentlemen would not mind driving us into a cage. But they do not have the strength and so they are forced to shake our hands. "We greet you," they say.

The attitude the capitalists have toward us depends on the correlation of power. You know what attitude capitalists adopted toward us during the first years of the revolution. But now they are forced to take account of us and they have started shaking our hands, although it must be said that we have always been ready to offer our hand. Why is it that they have now started taking account of us? It is because we have now become strong, because socialism cannot now be cast off. Even Dulles was forced to admit this during the last period of his life. Other ideologists of imperialism now also speak about this. They are forced to take account of us and to greet us when they meet us.

If, in our economic competition with capitalist countries, we lag behind, they will unwillingly stretch out their hands and then think: "Is it worth it to stretch out our hands to them or could we, perhaps, kick them with our foot in a certain place?" That is why the question of the time factor, of gaining time in economic development, primarily in the construction of power stations, is the main question. The water we propose to use to produce power at hydroelectric stations will flow away, but new water will come and we will stop it. We will build dams and will force the water to work for the people. The power of rivers will not leave us. But if we were to concentrate on the construction of hydropower stations, we would lose time and time cannot be regained. That is why there cannot be any argument as to which power stations are better, thermal or hydroelectric.

I remember reading a story in my primer as a child. Many of you will, no doubt, recall it. It is the story of how a dog, a cow, and a horse argued as to whom the master needs most. We do not have to start such an argument. If we think correctly, there can be no argument as to which power stations are more needed for Socialist construction. Both are essential. But those which arm our country with power more quickly, and make its economy unassailable and formidable in its competition with capitalism, and more important. I repeat:

There can be no argument as to which is better. Both are good. Hydropower stations would be better if they could be got more quickly. But at the present stage, thermal stations are better because they become operational more quickly. It goes without saying that one could agree to the preferential development of hydropower stations if the difference in time were not great; say, 1 year. But one cannot agree to a building time of 2 or 3 years. That is not just a little time, but a long period.

Comrade Novikov. We shall straighten out this matter.

Khrushchev. Correct it! Correct it! We make a strong plea: Correct it. It should be said, comrades, that power industry builders have made a lot of progress in the field of power industry construction and the development of engineering. But certain scientists and engineers still hold firmly to old things. I think that in the construction of hydropower stations, we still have a lot of things which we could and must quickly get rid of if we want to speed up the construction of hydroelectric stations. In the remote past an engineer worked out the details of the organization of construction and this organization of work exists to the present day, although it is out of date and holds us back in time, in organization, and in machinery. For a lot depends on the organization of construction.

CRITICISM OF CONSTRUCTION TECHNIQUES

At this point I would like to criticize some of your colleagues. When ministry heads reported to me on the construction of power stations, it was obvious that they were well prepared. They had prepared all kinds of papers, made calculations, hung up diagrams, and barricaded themselves all around with blueprints and drawings. They brought a model of the Saratov hydropower station. They made a good report. Here, they said, was prefabricated ferroconcrete. We want to touch Khrushchev's heart. What is hydroelectric station this will be! They said that the Saratov hydropower station would, in time and cost, compete with certain thermal stations. We welcome this. Let us have more such stations and cheaper ones. I liked the ideas of building Saratov GES without a special spillway dam. According to the project, the discharge of water will be carried out through the station. Experts say that it is a progressive idea and as this idea has been included in the project, it has ben pondered upon and can be realized. This makes the construction cheaper. I would like to praise this project and at the same time to criticize it. Of course, it is possible to plan such organization of construction, as has been done in the designs, with the presence of advanced machinery. I saw such machinery at the Bratsk, Kremenchug, and other building sites. I do not speak of Kuybyshev station. It has been built under different conditions, on a different technical basis and with different technical equipment. This must be taken into consideration and one must not simply say that such a construction head is wise and such a head is not as wise. One must take into consideration material opportunities which enable the heads better to show their abilities in organization, enable the builders to raise productivity and to step up the rate of construction. Even to kill a louse one must be not only brainy, but one must also have a fingernail with which to crush it.

This is a small deviation. Let us return to the project for the construction of Saratov GES. I looked into this project. It provides for the construction of the station in stages. I think this is correct. I have learned to understand these problems a little, as fate brought me into touch with you fellows long ago, probably 35 years ago.

The project shows a gantry crane. Why a gantry one? I think that such a crane limits the assembly workers, does not open a wide front. Builders have no elbow room and little can be done without elbow room. Of course, one must look into it. Maybe a gantry crane is convenient. But then one must have several such cranes so as to carry out work simultaneously on a wide front. It would be wiser to organize construction from large assemblies. Let us take, for example, the construction of blast furnaces. I see Comrade Dymshyts is here. Under his guidance the method of building blast furnaces from extended assemblies by means of assembling them on the ground was introduced in Zaporzhye. This made it possible to expand the scope of construction. What does it mean to enlarge assemblies? It means to increase the scope of the building site and then to erect at once the large assemblies. Engineer Dymshyts has achieved this in assembling the Zaporzhye blast furnace. It was assembled in 3 months. This is incredible. If he had started from the foundations and finished the assembly by mounting the last components, as we used to do in the old way, such achievements would be impossible. But he began working in a different manner, made his assemblies larger and at once advanced with gigantic strides.

At hydropower stations 10 or more turbines are mounted in a single long row. What is the organization of their assembly? The gantry crane provided for in the plan has assembled one of the turbines. Everything has been done. The last nut has been put into place, the water has begun flowing, and the turbine has been put into motion. Then the crane approaches the second turbine. The work on this turbine is finished. It is also put into motion. Then the work starts on the third turbine, and so forth. How much time is lost between the putting into operation of the first and the last turbine?

Comrade Aleksandrov, you put into service the first turbine at Stalingrad station a year ago. And when do you expect to put into service the last turbine?

ALEKSANDROV. Next year.

KHRUSHCHEV. In which month? The next year has 12 months.

ALEKSANDROV. Next year we shall put into service another 10 turbines.

KHRUSHCHEV. In which month?

ALEKSANDROV. It will depend on the supply of equipment.

KHRUSHCHEV. You see what kind of a diplomat he is. He could compete with Comrade Gromyko, our Foreign Minister.

You, of course, may think that I do not understand these matters well, as I am not a builder, but I wish to understand you. Tell me. When did you get that head of water behind the dam?

ALEKSANDROV. Last year.

KHRUSHCHEV. Which month?

ALEKSANDROV. In November.

KHRUSHCHEV. That means a year ago. And how many turbines are in operation?

ALEKSANDROV. Ten.

KHRUSHCHEV. That is from the total number of 22 turbines. I consider that it is possible to do it this way: Once you have built your dam, the river is barred and the head of water is there and all the turbines are on the same level. That means that it is possible to put into service not one but all turbines. Is it not so?

(Voices in the hall: "Yes, correct.")

The question is, then, why is it necessary when the head of water is there and one turbine is put into operation, for the mounting of the other turbines to drag on for several years?

PROBLEMS OF EQUIPMENT SUPPLY

You are flogging yourselves, comrades. In the baths, they beat themselves with branches, but you, comrades, are not beating yourselves with branches, and are not doing it in your baths either. Why is this? You yourselves are worsening the economic indices for building hydroelectric power stations. What is it that prevents you from putting not one but 22 turbines into operation at the same time?

(Voices from the audience: "That depends on the deliveries of equipment.")

Comrades, as the saying goes, you must use your brains. If you've designed a turbine, made the blueprints, checked everything—that is, if you've done all the complicated engineering and technical work, the brainwork—then it's easier to do the rest. Making 1, 20, or 100 turbines at a time, that's a question of capacity. Think which is more advantageous for us, to extend the period of the commissioning of turbines over 2 or 4 years, or to expand the production base of turbine construction so as not to give the builders one turbine at a time, like giving a patient medicine a teaspoonful at a time, but to give at once what is needed to insure a more rational assembly at the site.

That's how I see this business. And I want to ask: Why are you working in this old way? Well, somebody in the hall reported that there was a holdup in equipment. But you too want a kick in the pants, so that you would demand more insistently: "Give us enough equipment. Don't disgrace the hydroelectric power station builders." Isn't that right? (Voices from the hall: "Yes, yes.") It's cheaper for us to extend the production base for the construction of hydro equipment, turbines, and so on, than to delay the getting of electric power for several years. It's a clear case. Introduce progressive methods, and build economically.

Now I will return once again to our talk with the workers who reported to me about the further development of our power engineering. When I criticized them, they asked me, "Can we leave with you the model of the Saratov station?" I said, "Yes, I shall be very pleased." When I got back to Moscow, I noticed that it was an incomplete model, didn't I, Comrade Novikov? I looked at the model and saw that there was something missing. It turned out that you yourself had taken the draft for the organization of work which was appended to the model. You don't think so? I have the model in the Council of Ministers' building. Should I bring it here, to you? You left me one model with one aggregate, and showed me a model with a draft for the organization of work, on which the construction of the station stage by stage was shown. It turned out that after being criticized, you gave up the scheme for stage-by-stage assembly.

I'm glad that the criticism got as far as the minister, that the ministry workers didn't dig their toes in, and got rid of that draft for the organization of work, although they nevertheless left the gantry crane. I have already said that I think it's better to use a tower crane for assembly work than a gantry crane. If it's advantageous to use gantry cranes, then you have to have several of them, so that you can carry on the work over a broad front, in order to assemble not one aggregate, but several at a time.

Briefly, the number and type of cranes should be calculated so that the work would not proceed in an amateurish way. Well, Comrade Novikov, is that enough criticism? I think so.

SOVIET LAG IN STEAM TECHNOLOGY

When we had heard the power engineers, the designers, Comrades Shchevmlev and Shubin-Shubenko gave their opinions. I don't know whether Comrade Shubin-Shubenko was speaking the truth or whether he was handing me a line. I haven't any right to doubt him, but if he was handing me a line, he was doing it for a good cause.

He said: "We are now lagging behind in turbine construction. Our steam turbines are roughly 3 percent behind the Americans in fuel consumption."

I asked why. He answered that to improve turbines, we needed new equipment, and that laboratories were needed to carry out experimental work. I have no reason not to believe you, Comrade Shubin-Shubenko, although I know that sometimes designers can hand out a line to get more means, and in this case I am ready to support Comrade Shubin-Shubenko. We must not stint means on equipment for experimental work. Because without experimental work, it is difficult to progress in the development of technology.

Not to carry out research is the same as going down into a mine with a miners' lamp, although electricity has now been introduced, into the pit where there is no gas, in order to set up better working conditions for the coal-cutting operators. A good searchlight beam is needed in questions of technology. In effect, research work is just that beam and it must be developed in all fields of the national economy. Sometimes they say that the Gosplan provides little allocation for research work. The Gosplan provides for everything intelligent, but sometimes you yourselves ask for allocations from the Gosplan for various sorts of rubbish, giving as your grounds the necessity of research work, and when they have once caught you out on it, then the Gosplan turns down your good suggestions, too, thinking that you were indulging in self-seeking.

I'm not saying this to Comrade Shubin-Shubenko, but in general. Perhaps such a warning may be useful.

I would like to say one more thing, but with large reservations, since I know how dangerous it is for us fellows, the politicians, to speak on technical questions among major scientists, engineers, and practical builders.

TECHNOLOGICAL PRODUCTION PROBLEMS

This idea consists of the following: Power generators at our hydroelectric stations have a great weight and a small speed of revolution of the rotor in the stator. Now what would happen if we were to

make not only the rotor but also the stator revolve, but in the opposite direction? It looks as though, with such a scheme, one could lower the weight of the machine, save metal and perhaps obtain other advantages. I do not know to what extent this is technically possible. I find that difficult to say. But I may express a wish: I have thrown you a fly and it is up to you to cope with it. If you can catch it, people will thank you. If you cannot, that will be that. But it is still worth thinking about. I think such problems should be considered at the scientific conferences. Some of our scientists remain in their studies and sometimes keep secrets from themselves to prevent anyone from hearing their thoughts. They are afraid of even saying them aloud. This can only do harm. Problematic questions must be widely discussed. The attention of larger sections of the public must be drawn to them to enable creative thought to develop in all branches of science and technology.

A few words about electric grids. The question of power transmission is now acquiring great importance. It is a long time since copper was replaced by aluminium in electric lines. That is very good. This switchover has opened up great possibilities of carrying on work on a large front, because aluminium is not in short supply in our country and we can get as much of it as we need, while copper still produces certain difficulties. To prevent losses of electric power when it is transmitted over long distances, the solution of the problem of using direct current must be speeded up. In the construction of power transmission lines there must be a total switchover to ferroconcrete supports. I was shown photographs of good ferroconcrete supports. But the trouble is that such supports are as yet produced in very small quantities.

Our industry has mastered and is making the production of big transformers, generators, and other items of modern electrical equipment. But owing to the lack of cold rolled steel for magnetic lines, ordinary steel is used which leads to 2.5 times more losses of power. The metallurgical industry must pull itself together and meet all the cold rolled steel demands of the power industry.

Works making boiler equipment still supply boilers rather than bit by bit in large units. This greatly slows down and increases the cost of the assembly of power stations. The construction and assembly of power transmission lines and substantions lags behind the plan owing to insufficient supplies of wire, transformers, and apparatus.

Our industry must organize the mass production of complete substations for towns and, especially, for the countryside. Without this the complete electrification of the country and the supply of power to every consumer with minimum losses is impossible.

NEED FOR RATIONAL USE OF ELECTRIC POWER

Recently the Central Committee of the party adopted a letter on the rational use of electric power in the national economy. The rational and economical consumption of electric power must become a nationwide concern. But I would like this appeal of the party to be understood correctly. It must not be interpreted in such a way that the economy of electric power can harm production. A struggle must be waged against squandering, remembering that squandering has never been a sign of wealth. It is rather a sign of stupidity. That

is why, even under communism, there will not be a "drink galore" land. If there should be any abnormal people who turn on the tap to make the milk flow into the river, such people will be immediately checked. They will get a rap on their knuckles and will be told: "You fools, what are you doing?" And even if they should start explaining that they did that in accordance with their needs, they will be told that it is not a need but stupidity.

To live in a Communist society, one must prepare properly and in advance. One should not do stupid things under socialism. We must run our economy wisely and prudently.

Recently a decision was taken on the saving of nonferrous metals—copper, nickel, and others. I wish you to understand this correctly. We by no means wish to save nonferrous metals through the deterioration of machines, machine units, or instruments. We have sufficient materials for this purpose. But we cannot waste nonferrous metals where we can do without them. For example, architects order chandeliers and factories work according to the principle: "The heavier the better, the more money they will be paid." It happens that an architect or an artist designs various fixtures which can be made light and delicate, and a factory endeavors to increase their weight. We get chandeliers weighing several tons, and this work is paid according to the weight of the article. The state has to pay and those who make such articles have it easy, they have received their payment and say to themselves: "Those who approve such projects are rather silly but it is easy to live with them."

It is essential to eliminate wastefulness in the use of nonferrous metals but we must economize not for the sake of economizing. It would be a crime to aim at economies in nonferrous metals where we cannot do without them. The matter concerns the prevention of expenditure of these metals where they are not essential.

Those who visited warships could see how many ornaments there were made of brass and copper. Aluminum was unknown in the past and, furthermore, only few ships were built under tsarism. So they adorned the saloons of aristocratic officers with copper. Aluminum or plastics can now be used instead of copper. They are better, warmer, and more hygienic. The designers must pay attention to this. Where copper is used for ornaments as a tribute to the past it must be replaced.

I have criticized more than once designers and builders who use timber for the construction of housing instead of ferroconcrete and other materials. I was told that the Bratsk GES builders, too, had had some anxiety that they, too, would be criticized for the construction of timber houses. I consider that the builders of Bratsk station acted correctly. It would be unwise to settle near the forest and then go to Kuybyshev to fetch building materials. But this example cannot be regarded as a rule. The present new methods of construction enable us to build more permanent and economical buildings.

It is necessary, as a rule, to build four- and five-story houses, which are the most economical. In five-story houses the apartments on the lower stories should be allocated to families, and the fifth story should have a corridor system and rooms for single persons and newly married couples. They could live there while they are childless, and then could be transferred to apartments. Thus we shall display solicitude for people and prevent wastefulness.

It is fully appropriate, on the basis of cheap current supplied by powerful hydro stations in Siberia, to set up in their direct vicinity current-consuming undertakings; for example, large aluminum factories, chemical industries, and other undertakings.

Plans must be drawn up in such a way that new undertakings would be situated on the whole near large power stations under construction. These undertakings should be built at such a rate as to put them into service simultaneously with the power stations. Apart from that, temporary accommodations should not be built for the constructors of hydropower stations. Permanent, well-appointed settlements should be built. The constructors will then live in good conditions, and when they go to another building site, these accommodations will be handed over to the workers of the new enterprise. Thus both builders and factory workers will have good living conditions.

Allow me to dwell also upon some problems of the electrification of the countryside. In this we are lagging behind considerably. In the past no attention was paid to this matter. Thanks to measures taken by the party Central Committee and the government, considerable successes have been achieved in the development of agriculture.

RECLAMATION DEVELOPMENTS

The production of grain and livestock produce has gone up sharply. During the past few years the State has increased its agricultural investments and the country has gotten a good return for it. Let us take the reclamation of virgin lands as an example. During the past 6 years—that is, from 1954 to 1959—the state invested 37.4 billion rubles in the reclamation of virgin and wasteland. In this period the marketable output of grain in virgin lands yielded an additional income of some 62 billion rubles for the state budget. As a result of the reclamation of virgin lands, the state made a net profit of over 24 billion rubles. Moreover, as a result of the same investments in virgin lands, the production funds of sovkhozes, RTS, and procurement organizations increased by almost 30 billion rubles.

It emerges that the expenditure invested in the reclamation of virgin land has been recouped in a few years. It is a pleasure to hear that this year's purchases of meat are double those of 1953 and purchases of milk are almost 2.5 times greater. Only recently I read reports by correspondents of bourgeois papers. They say that there are lots of products in the shops. Housewives can come to the shops with bags of any size and fill them with various articles. Traders even come out onto the pavements and do their trading there. To all of us it is also a pleasure to see that Moscow is not a jungle, that people here do not run about asking where they can buy some milk.

IMPROVEMENTS IN AGRICULTURE

Now people know that in shops selling milk one can buy milk of the desired quality in adequate quantities, as well as other products. Kolkhozniks have done a good job. These successes are a joy to each of us. The situation in agriculture has changed considerably during the past few years. At the end of 1949 I left the Ukraine, came to work in Moscow, and soon went to the southern regions of Moscow Oblast. Comrade Stalin asked me upon my return: "Tell me what

you saw, your opinion of the state of affairs?" I answered: "Many buildings and houses are destroyed. Here and there windows are stuffed with straw. There are no panes. The main thing is that many people lack interest in increasing kolkhoz output. The young men have gone into the towns. The girls have remained alone. They have no one to marry."

You laugh, but it is natural: young men and girls must marry. And mothers said: "My daughter is a bride, but what she is wearing is all she has." Such was the situation. But now things are improving. When you come to a kolkhoz, it is a pleasure to look around. A peasant woman comes out well dressed. From afar you cannot tell whether she is old or young. And there are more lands in the villages, too.

The material interest in the development of kolkhoz production has increased . Our young people have grown up. They are toiling gloriously in production, on building sites, in kolkhozes and sovkhozes. I have already mentioned the speech made by Valentina Zharkaya, a concrete worker of the Bratsk power station building site. Such builders are the heroes of our time. Is the old days, office girls were thought of as distinguished. They represented, as it were, the upper class.

It can now be said that among us the person engaged in physical labor, as regards clothing or intelligence, is indistinguishable from the person engaged in mental work. You have heard how logically and convincingly and with what consciousness of her grandeur and her dignity this girl spoke and described with pride her work as a concrete worker.

NEED FOR RURAL ELECTRIFICATION

It is necessary, comrades, to solve the task of electrification of the countryside. We know what great attention was paid by Vladimir Ilyich Lenin to the question of electrification of the countryside. The appearance of electric lights in the countryside was connected by the peasents with the name of Lenin. They said with love: "In our village, too, Ilyich's bulbs have been switched on."

It is necessary to admit that there was also a time when an incorrect attitude was adopted toward electrification of the countryside. There existed a prohibition against giving electricity to the villages from state power grids. Heaven forbid! Every kolkhoz had to produce power by its own means. I remember that in 1959 the secretary of the Moscow Obkom of the party, Comrade Popov, said to me: "We have solved an important problem set by Lenin. We have electrified the Oblast."

Then I understood what sort of electrification that was and it turned out that it was the sort of electrification of which one should be ashamed. They took all captured and technically exhausted motors and, under the guise of "patronlike" (shefskiy) aid, shoved them onto the kolkhozes. Electricity generating machinery was attached to the motors and then they sent a bill to the kolkhozes. The collective farmers said: "But we thought that you had given us this old stuff free."

Well, you now the psychology of the peasant. He will take anything as long as it is free. As they say, "Don't look a gift horse in

the mouth." But it happened that when they had a good look at the teeth of this horse, they saw that the teeth were rotten. And on top of that, the Gosbank wanted big money. These collecive farmers began to get indignant. As a result what happened was not electrification but distortion. It is understandable that such electrification was not needed by the collective farmers.

The electrification of the countryside must be carried out with thought and according to regions, so that it would really be a Leninist electrification. It is expedient that where a state power grid passes, kolkhozes should be connected with it, and where there is no power grid, a branch line should be constructed. For kolkhozes situated far from state power grids, it is necessary to work out standard designs for regional rural power stations, so that they could be most economical and that agriculture could get cheap power. The kolkhozes can do this on their own account. Given the present economic situation of the kolkhozes, such work would be within their capabilities. It is necessary to widely develop, on cooperative principles, the construction of high-voltage and distribution networks, substations, interregional and interkolkhozes electric power stations. Kolkhozes will contribute their money and the state organizations must give the necessary aid. Having implemented the electrification of the countryside, we shall do a very good thing for the kolkhoz peasantry, for the whole people and for the acceleration of our common movement along the path toward communism.

The feats of the building workers are highly assessed by the whole of our people.

SIGNIFICANCE OF THE LONG-TERM PLAN FOR ELECTRIFICATION

Comrades, in conclusion I should like once again to speak about the significance of the long-term plan now being worked out for the electrification of the country. This plan is an inalienable and integral part of the program of our party, the program for the construction of communism. Without electrification there is no mechanization or automation of production, and without mechanization and automation there will be no increase in the productivity of labor. Therefore, in order to increase the mechanization of work and increase the productivity of labor, it is necessary to implement electrification on an even more extensive scale. All branches of the national economy must be electrified and mechanized. This will insure an uninterrupted growth of labor productivity, so that we can catch up to and overtake the most highly developed capitalist countries in this important index within the shortest time. Without an uninterrupted growth in labor productivity, it is impossible to create an abundance of products so as to shorten the working day. This can only be achieved on the basis of electrification and automation of production.

That is why the builders of electric power stations and electric power stations and electric power networks are one of the foremost detachments of the builders of communism. All praise to you for your successes, and reproach to you as well if you fall behind in one sector or another of the fulfillment of your pledges for the implementation of the task of total electrification of the country.

You are in the most honorable sector of our construction, although on the whole there are no dishonorable sections in the work for the

good of society. At the basis of the entire life of society lies man's work. Nothing can be created without work. We must create all conditions for making every man's work highly productive and, at the same time, joyous, so that every man should feel the need to work. At one time many people did not understand, and even now there apparently are skeptics who doubts that the time will come when work becomes the first and vital necessity of every man. We have not yet come to that time, but we confidently march along the path of embodying in life this most important principle of communism. The fulfillment of Lenin's behest on the electrification of the whole country will create for us still more favorable opportunities for a successful building of communism, and for a further quick rise in all branches of the national economy on a modern technical basis.

What can be loftier and nobler than work for the benefit of society, for the sake of the happiness of the people and the coming generations? Builders, wherever they work, are putting up monuments for centuries. The big electric power stations built by you will be a living embodiment of the heroic labor of the Soviet people in the epoch of building socialism and communism. Therefore, one can say without exaggeration that you are creating outstanding monuments of our great epoch to last for ages.

We all are proud that the victory of the working class and the toiling people, the first in history, was won in our country. Having become masters of the situation, our people have created a Socialist society and are blazing the path to communism, the most just and perfect society on earth.

A large and honorable task has been entrusted to you, comrade builders. You have been fulfilling this task with honor. There can be no doubt that in the future as well you will fulfill it successfully. But I think that you would understand me wrongly if I did not call on you to organize your work better, to better use the material sources and possibilities for accelerating our progress along the path of building a Communist society.

THE SOVIET ECONOMIC CHALLENGE TO CAPITALISM

Comrades, the 21st Party Congress adopted a majestic program of Communist construction. The historic decisions of the congress, our 7-year plan, have been unanimously approved by all peoples of the Soviet Union, have been warmly welcomed by the working people of Socialist countries and by the progressive people of the world. This program cannot even be ignored by our opponents. In capitalist countries different commissions are being set up, and conferences are being called, to discuss reports on the development of the economy of the Socialist countries. Bourgeois economists, engineers, and scientists increasingly declare that the Soviet Union's 7-year plan is a real fact, and that the Soviet people are successfully implementing it. Bourgeois economists are now guessing what urgent measures must be taken by capitalist countries in order to prevent the Soviet Union from overtaking them in its economic development. The rapid growth of the Soviet Union's economy and that of all the countries of socialism, according to the admission of the bourgeois ideologists, is a serious challenge to capitalism. The mighty rise of the economy of

the Socialist countries is an attractive example to the economically underdeveloped countries striving to embark on the path which would correctly insure their independence and the steady rise of their economy, well-being, and culture.

Our opponents have been trying to turn communism into a scarecrow for ordinary people in capitalist countries. They act exactly like those who frighten backward people with the Devil by drawing horrible and fantastic pictures about hell. But these legends can influence in time only ignorant people. The propagators of the legends about the Devil take advantage of the fact that no one has ever seen or will ever see him. This kind of maneuver will no longer succeed with communism. Our opponents clamor: "When communism comes there will be an end to the free world." This reminds me of those grandmothers who frighten children with the Devil. I remember my grandmother used to say to me during my childhood, "One day the Devil will come and with him will come the end of the world. Doomsday will be upon us."

But one cannot rely on such fairytales for long. These days the truth about communism cannot be hidden. Times passes. Communism grows and flourishes. In 42 years the U.S.S.R. has not only overcome her age-old backwardness but has also become the first to launch a rocket to the moon. Capitalists are making one attempt after the other, but it does not work. They send a rocket up and it crashes down.

What is the matter? It looks as though communism is not as bad as its opponents would have us believe. People in capitalist countries are beginning to think. If we fulfill and overfulfill the 7-year plan and raise our living standard even higher—and we shall do it—it will be the world's highest standard of living. People will see the real character of communism and its fruits even better, and millions of working people will say, "If communism is bad for capitalists, may God give it to me as soon as possible."

Communism is now beginning to be understood and grasped not just theoretically but visually, in life itself. People see what communism gives to peoples, how it improves their lives. Socialist countries are producing a growing quantity of bread grains, meat, butter, footwear, and clothes, are building a growing number of residential units and are making culture flourish.

These are the elements of which live communism is composed. Only dogmatists and people who are quite divorced from life keep on repeating platitudes when they speak about communism. But life is moving on and communism is victorious in practice. During the years of the Soviet regime our country, previously half-starved and backward, has risen to great heights. That is communism in action. And these wonderful victories of communism were gained in our country in conditions under which almost two decades were taken up by war and the restoration of the economy destroyed by war. These days communism is not an abstract notion. It is a real thing being created by hundreds of millions of people marching along the road of Marxism-Leninism.

Comrades, several months have passed since we held the 21st Congress of our party. Now we are already beginning to prepare for the 22d CPSU Congress, which will examine a report of the Central

Committee and will adopt a new party program. That will be a program for the construction of communism in our country.

The Soviet people are sure that you builders of electric power enterprises will continue to be in the vanguard of Communist construction.

Long live our valiant builders of electric power enterprises, active fighters for the implementation of Lenin's great ideas about the country's electrification!

The names of those who laid the foundations of socialism, who built socialism, and are now building communism, will live forever. The coming generations will honor them as heroes of our glorious epoch. Glory to you, comrades, builders. Long live our Leninist Communist Party. Long live the victory of communism.

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